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Forum to Review Confined Disposal Facilities for Dredged Materials in the Great Lakes.: Report of the Dredging Subcommittee to the Great Lakes Water Quality Board

Dredging Subcommittee

Great Lakes Water Quality Board

International Joint Commission

A Forum to Review Confined Disposal Facilities for Dredged Materials in the Great Lakes

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to the Great Lakes Water Quality Board

Windsor, Ontario
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Contents

CONTENTS (Cont'd.)

CONTENTS (Cont'd.)

Figure

Tables

Acknowledgements

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Introduction

The sediments of harbours and channels throughout the Great Lakes are routinely dredged to maintain adequate depths for ship traffic. Historically, the dredged materials have been disposed in nearby areas of the lakes and channels. However, discharged wastes from municipal and industrial sources, as well as runoff from nonpoint sources, have resulted in accumulations of contaminants in sediments. The concentration of these contaminants is often many times higher than in the overlying water. Although the fate of these sediment-associated contaminants has been, and remains, unclear, the relatively high concentrations in sediments has caused widespread concern over their potential effect on the Great Lakes environment. Based upon the presumption by the agencies responsible for dredging and for environmental protection that containment of the dredged material produced from areas with contaminated sediments was in the best public interest, efforts to confine dredged materials were initiated. By the mid-1970s Confined Disposal Facilities (CDFs) came into widespread use in the harbours and along shipping channels of the Great Lakes as the predominant method of confining dredged materials from contaminated areas of the Great Lakes (Figure 1).

Following the Great Lakes Water Quality Agreement of 1972, the International Joint Commission (IJC) established the International Working Group on the Abatement and Control of Pollution from Dredging Activities to review and consolidate information on dredging in the Great Lakes. Under the revised Great Lakes Water Quality Agreement of 1978 the Dredging Subcommittee (DS) was formed under the auspices of the IJC's Great Lakes Water Quality Board. Reports of the Working Group (1975) and the Dredging Subcommittee (1982, 1983) reviewed and summarized dredging activities, and provided a dredging register and guidelines for the evaluation of Great Lakes dredging projects.

About eight times more dredging occurs within the United States portion of the Great Lakes than in the Canadian portion (DS, 1982). During the period of low water levels on the Great Lakes from 1966 to 1972, an average 8.7 million m^3 was dredged annually (Working Group, 1975). Most of this material was discharged in the open lake at the most convenient and economical site. During the period 1975-1979 when lake levels were much higher, about 4.6 million m^3 were dredged annually from Great Lakes harbours and channels (DS, 1982). Because open lake disposal became restricted during this period, 58% was placed in CDFs while 38% was deposited in open water, with the remaining 4% being disposed elsewhere. Water levels in the Great Lakes have remained high since the 1975-1979 period. Anticipated future lower water levels would require increased dredging if harbours and channels are to be fully utilized.

Various federal, state and provincial legislations, policies and criteria form the basis for the construction of CDFs in the Great Lakes (DS, 1982). The CDFs in the Canadian portion of the Great Lakes are shown in Table 1.

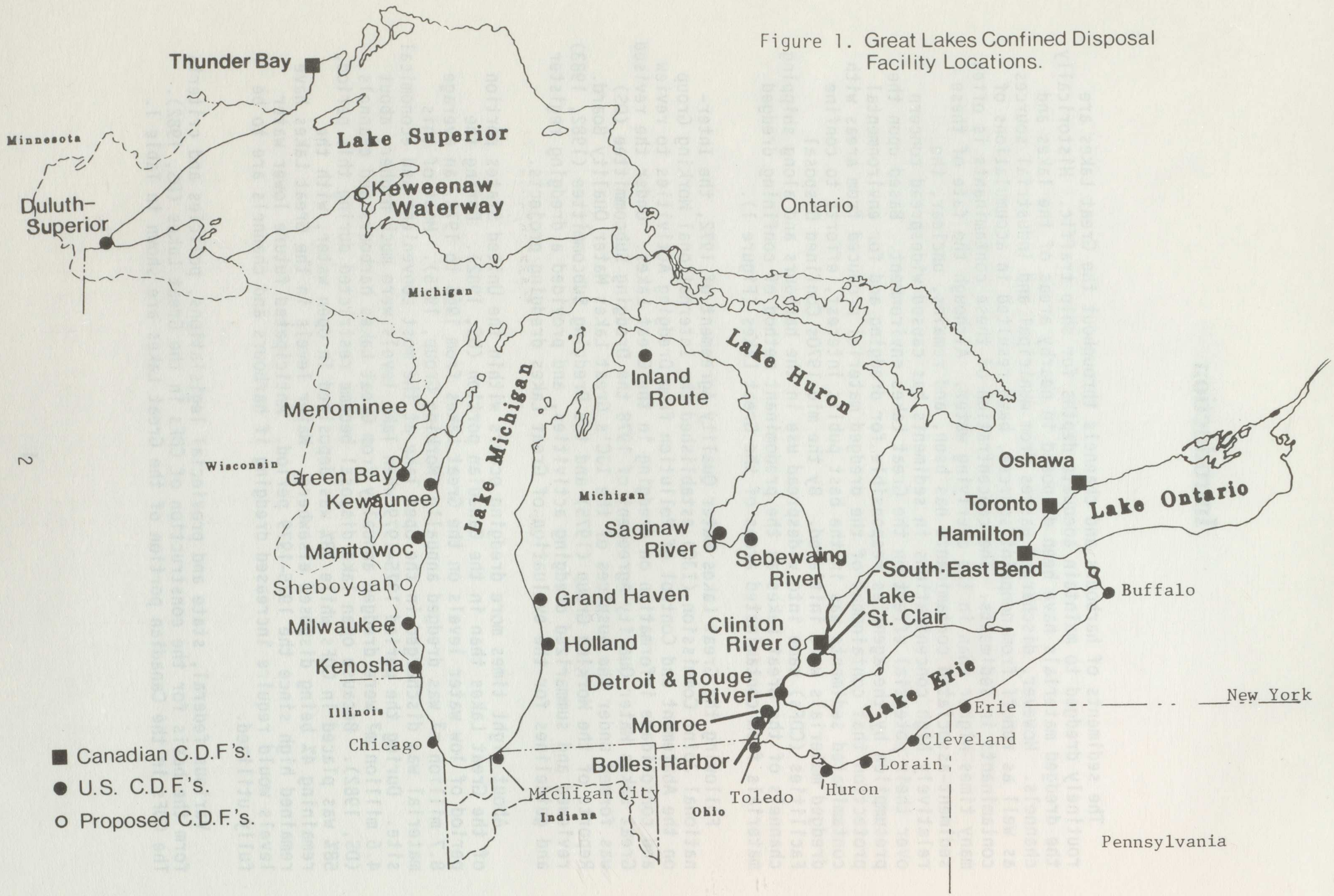

Figure 1. Great Lakes Confined Disposal Facility Locations.

TABLE 1. CONFINED DISPOSAL FACILITIES IN THE CANADIAN PORTION OF THE GREAT LAKES SYSTEM

LOCATION	NAME	TYPE (a)	INITIAL CON-STRUCTION FUNDING	NAVIGATION PROJECT SERVED	YEAR CONST. COM-PLETED	AREAL SIZE (HECTARES)	DESIGN CAPACITY (M^3)	PERCENT FILLED	YEAR TO BE FILLED TO CAPACITY	BENEFICIAL USES: EXISTING OR FUTURE	TO DATE CONSTRUCTION COST
Thunder Bay (Lake Superior)	Mission Bay Disposal Facility	L	Public Works Canada	Thunder Bay Harbour	1978	81	3,000,000	33	2000	Public Park	$6,500,000
S.E. Bend Cut-Off Channel (St. Clair)	S.E.B. Disposal Facility	L	Public Works Canada	S.E. Bend Cut-Off Channel	1977	28	350,000	125(b)	1982	Undetermined	$3,900,000
Oshawa (Ontario)	Oshawa Disposal Facility	L	Public Works Canada	Oshawa Harbour	1981	3.5	90,000	40	1990	Possibly Wharf/Pier	$1,000,000
Hamilton (Ontario)	Bayside Disposal Facility	L	Hamilton Harbour Commission	Hamilton Harbour	1972	57	3,000,000	75	2000	Commercial/ Industrial	$1,800,000
Toronto	Outer Harbour East Headland	L	Toronto Harbour Commission	Toronto Harbour	1985	50.4	3,010,000	10	2010	Recreational/ Wildlife	$4,000,000

(a) L: In-lake; attached, along or adjacent to shoreline.

(b) Including decant cells.

The CDFs in Thunder Bay, South-East Bend Cut-Off Channel, and Oshawa were constructed by Public Works Canada (PWC) from their capital allocations for dredging projects at these locations. Total initial combined cost of the three facilities was approximately $7.0 million. Transport Canada has now assumed responsibility for the maintenance of, and for any additional construction required for these three facilities. The CDFs in Hamilton and Toronto were funded and constructed by their respective Harbour Commissions. The total construction costs to date for the facilities in Hamilton and Toronto are $1.8 million and $4.0 million, respectively.

In the United States, an amendment to the Rivers and Harbor Act, Section 123 of PL 91-611, created a CDF program to contain ten years worth of polluted dredged material to be removed from federal Great Lakes navigation projects with an estimated cost of $350 million. The U.S. Army Corps of Engineers is charged with responsibility to design, construct and operate those CDFs. Currently, 37 U.S. federal projects require CDFs (down from 77 originally classified as polluted). Certain navigation projects will share a common CDF, and 29 CDF structures will serve these 37 projects. Of the 29 CDFs that are anticipated as being needed, 25 have been constructed to date. Table 2 lists complete CDF structures authorized for the expressed purpose of containing polluted dredged materials. Six additional disposal sites are listed which predated the U.S. Great Lakes Confined Disposal Facility Program. It was hoped that following the ten-year time period, point source pollution control activities would have sufficiently reduced the introduction of pollutants to the point where new sediments would be clean enough to preclude the need for confinement.

In light of the effort and funds expended on CDFs in the Great Lakes and our rather unique experiences with these facilities, the Dredging Subcommittee saw the need for a Forum with the following objectives:

1) to discuss the history and future uses of CDFs in the Great Lakes;

2) to share current information on the design, construction, operation, and maintenance of CDFs;

3) to relate research and experience on the performance of CDFs in isolating contaminants from the aquatic environment; and

4) to provide for the exchange of information on experiences in the design, construction, and operation and maintenance of CDFs in the Great Lakes and other locations in North America through the presentation of case studies.

TABLE 2. CONFINED DISPOSAL FACILITIES IN THE U.S. PORTION OF THE GREAT LAKES SYSTEM, PAGE 1 OF 4

LOCATION (City, State)	NAME	TYPE (a)	91-611 (b)	NAVIGATION PROJECT(S) SERVED	YEAR CONST. COM-PLETED	SIZE (Hectares)	CAPACITY (M³)	PERCENT FILLED	YEAR TO BE FILLED TO CAPACITY	BENEFICIAL USE(S) EXISTING OR PLANNED	CONSTRUCTION COST (Contract Payments)
BUFFALO DISTRICT											
Toledo, OH	Toledo, OH	L	N	Toledo Harbor, OH	1967	150	3,822,500	100	1978	Wildlife Area	$ 5,000,000
Toledo, OH	Toledo, OH	L	Y	Toledo Harbor, OH	1976	242	7,645,000	65	1992	Wildlife Area	18,400,000
Huron, OH	Huron, OH	I	Y	Huron & Vermillion Harbors, OH	1975	63	1,643,675	70	1990	Small Boat Harbor & Park	6,400,000
Cleveland, OH	Dike #12	L	Y	Cleveland & Rocky River Harbors, OH	1974	56	2,110,020	100	1979	Water Front Development	6,800,000
Cleveland, OH	Dike #14	L	Y	Cleveland & Rocky River Harbors, OH	1979	88	4,686,385	40	1991	Recreation/Park	28,300,000
Erie, PA	Erie, PA	L	Y	Erie Harbor, PA	1979	23	1,223,200	40	1993	Industrial Development	1,600,000
Buffalo, NY Harbor	Small Boat	L	N	Buffalo Harbor, NY	1968	33	1,146,750	100	1972	Wildlife Area	500,000
Buffalo, NY	Times Beach	L	N	Buffalo & Dunkirk Harbors, Black Rock Channel & Little River, NY	1972	45	1,146,750	20	(c)	Wetland	500,000

(a) U=Upland CDF; L=In-lake CDF - adjacent to land; I=In-lake CDF Island.

(b) Built under authority of PL 91-611; Y=Yes; N=No.

(c) Filling of CDF was permanently terminated due to development of a wetland which serves as a unique wildlife habitat.

(CY) Cubic yards

TABLE 2. CONFINED DISPOSAL FACILITIES IN THE U.S. PORTION OF THE GREAT LAKES SYSTEM, PAGE 2 OF 4

LOCATION (City, State)	NAME	TYPE (a)	91-611 (b)	NAVIGATION PROJECT(S) SERVED	YEAR CONST. COM-PLETED	SIZE (Hectares)	CAPACITY (M^3)	PERCENT FILLED	YEAR TO BE FILLED TO CAPACITY	BENEFICIAL USE(S) EXISTING OR PLANNED	CONSTRUCTION COST (Contract Payments)
BUFFALO DISTRICT (cont'd.)											
Buffalo, NY	Dike #4	L	Y	Buffalo & Dunkirk Harbors, Black Rock Channel & Little River, NY	1977	40	5,275,050	40	1995	Wildlife Area	15,400,000
Lorain, OH	Lorain, OH	L	Y	Lorain Harbor	1977	58	1,414,325	70	1990	Small Boat Harbor & Recreation	7,900,000
CHICAGO DISTRICT											
Michigan City, IN	Michigan City CDF	U	Y	Michigan City Harbor, IN	1978	3.3	19,113	80	1989	Recreational Park	286,626
Chicago, IL	Chicago Area CDF	L	Y	Chicago River, IL Chicago Harbor, IL Calumet Harbor & Calumet River, IL/IN	1984	42	993,850	10	1995	Recreational and Industrial Park	7,841,137
DETROIT DISTRICT											
Bolles Harbor, MI	Bolles Harbor, MI	L		Bolles Harbor, MI	1977	24.6	256,107.5	25	1990	Marina Expansion	895,908
Monroe County, MI	Pte. Mouille, MI	I	Y	Detroit & Rouge Rivers, MI	PH I/78 PH II/81	685	14,250,280	38	1993	Hunting, Fishing & Marsh Reclamation	50,869,074
Dululth, MN	Erie Pier, MN	L	Y	Duluth-Superior Harbor, MN & WI	1978	82	764,500	50	1993	Recreational	993,035

TABLE 2. CONFINED DISPOSAL FACILITIES IN THE U.S. PORTION OF THE GREAT LAKES SYSTEM, PAGE 3 OF 4

LOCATION (City, State)	NAME	TYPE (a)	91-611 (b)	NAVIGATION PROJECT(S) SERVED	YEAR CONST. COM-PLETED	SIZE (Hectares)	CAPACITY (M^3)	PERCENT FILLED	YEAR TO BE FILLED TO CAPACITY	BENEFICIAL USE(S) EXISTING OR PLANNED	CONSTRUCTION COST (Contract Payments)
DETROIT DISTRICT (cont'd.)											
Frankfort, MI	Frankfort Harbor, MI	U	Y(d)	Frankfort Harbor, MI	1982	(d)	81,801.5	0	1990	Marina Facilities	835,769
Grand Haven, MI	Grand Haven Harbor, MI	U	Y	Grand Haven Harbor, MI	1974	36	236,995	97	1985	Public Use	566,498
Green Bay, WI	Green Bay Harbor, WI (Island site)	I	Y	Green Bay Harbor, WI	1979	60	917,400	97	1986	Recreational	4,693,300
Green Bay, WI	Green Bay (Bayport land site)	U	N	Green Bay Harbor, WI (e)	(e)	400	229,350	100	1979	Industrial Development	123,537
Detroit, MI	Grassy Island	I	N	Rouge River, MI	1960	80	1,452,550	100	1984	Wildlife Area	1,272,336
Holland, MI	Holland Harbor, MI	U	Y	Holland Harbor, MI	1977	27.7	282,865	75	1988	Park Facilities	1,326,830

(d) Holding area only, material trucked upland. Value engineering change proposal was accepted, moving disposal area to private site. Original dike was backfilled with gravel.

(e) The original disposal facility was constructed by the City of Green Bay in 1965, as local sponsor for new work deepening. The site was used by the Corps for disposal of material from the new work harbor deepening. In 1977, portions of this site were modified by the Corps for disposal of maintenance dredging under PL 91-611, which was enacted in 1970 and superseded previously enacted legislation until ten years of maintenance dredging is contained.

TABLE 2. CONFINED DISPOSAL FACILITIES AROUND THE U.S. PORTION OF THE GREAT LAKES SYSTEM, PAGE 4 OF 4

LOCATION (City, State)	NAME	TYPE (a)	91-611 (b)	NAVIGATION PROJECT(S) SERVED	YEAR CONST. COM-PLETED	SIZE (Hectares)	CAPACITY (M³)	PERCENT FILLED	YEAR TO BE FILLED TO CAPACITY	BENEFICIAL USE(S) EXISTING OR PLANNED	CONSTRUCTION COST (Contract Payments)
DETROIT DISTRICT (cont'd.)											
St. Clair County, MI	Dickinson Island (East & West Dikes)	U	Y	Channels in Lake St. Clair, MI	1976	174	1,529,000	48	1990	Wildlife Area	3,117,398
Emmet County,	Inland Route MI	U	Y	Inland Route, MI	1982	8.6	14,908	20	1992	Wildlife Area	176,226
Kenosha, WI	Kenosha Harbor, WI	L	Y	Kenosha & Racine Harbors, WI	1975	25	573,375	66	1990	None	7,230,463
Kewaunee, WI	Kewaunee Harbor, WI	L	Y	Kewaunee Harbor, WI	1982	28	382,250	57	1992	Recreational	2,224,686
Manitowoc, WI	Manitowoc Harbor, WI	L	Y	Manitowoc & Two Rivers Harbors, WI	1975	24	611,600	61	1992	Land Use Development	3,550,798
Milwaukee, WI	Milwaukee Harbor	I	Y	Port Washington & Milwaukee Harbors, WI	1975	44	1,223,200	44	1990	None	5,029,417
Monroe, MI	Sterling State Park	L	Y	Monroe Harbor, MI	1985	89	3,210,900	0	1995	10 Ac. for Nature Complex	35,660,000
Saginaw, MI	Saginaw Bay	I	Y	Saginaw River, MI (Lower River & Saginaw Bay)	1978	283	7,645,000	48	1990	Wildlife Area	15,268,378
Village of Sebewaing, MI	Sebewaing Harbor	U	Y	Sebewaing River, MI	1979	180	64,218	65	1989	Extension of Sebewaing Airport	988,770

Summary and Conclusions

The following summary and conclusions have been reached following the presentations of the invited speakers and discussion between the participants and Dredging Subcommittee members.

1. The use of CDFs for dredged materials is a common practice in Canada and the United States. However, construction of in-lake CDFs for the stated purpose of long-term disposal of contaminated material is unique to the Great Lakes.

2. In the Canadian portion of the Great Lakes, existing CDFs should fulfill the needs for the forseeable future at Thunder Bay, Hamilton, Toronto and Oshawa. It is expected that new CDFs at the South-East Bend Cut-Off Channel and other Great Lakes connecting channels dredging project locations may be required in the future.

3. In the United States portion of the Great Lakes, special legislative authority and appropriations were provided to construct CDFs for the containment of polluted dredged materials from federal navigation projects. Under this authority 29 CDFs will be provided to serve 37 navigation projects. As of 1985, 25 CDFs have been built under this authority.

4. The siting of CDFs has been difficult and will become more troublesome because acceptable sites are limited.

5. Public participation is an essential component in CDF site determination and this participation should be encouraged in the early states of CDF site selection.

6. Funds for CDFs are expected to become more difficult to obtain in the future, and better justification in terms of preventing damage to the Great Lakes ecosystem will be needed.

7. In addition to the primary purpose of contaminated sediment confinement, unexpected benefical uses of CDFs have occurred in the past, especially in terms of wildlife. Some CDFs have been intentionally designed and constructed with specific beneficial uses in mind. Facility plans should consider these and other benefits.

8. Although sediment contaminant levels are believed to have decreased at many dredging locations, existing monitoring programs are inadequate to demonstrate conclusive trends. Nevertheless, contaminant levels at a number of locations render the sediments unacceptable for open lake disposal.

Recommendations

The Dredging Subcommittee recommends that:

- Comprehensive studies be initiated at selected CDFs representative of different construction types, contaminant types and dredging procedures to determine the fate of sediment-associated contaminants and the effectiveness of dredging and disposal in CDFs to remove and/or isolate environmental contaminants. Such studies must address:

  a) the efficiency of dredging and transport procedures in transferring contaminants to the CDF;
  b) the losses of contaminants from the CDF during filling; and
  c) the efficiency of filled CDFs in retaining contaminants, including the losses, if any, of contaminants from the CDF via particulates, water and biota.

- When dredging sediments are sufficiently contaminated to warrant confinement, dredging, transport, and CDF operations should utilize methods that minimize turbidity, solids resuspension and the loss of fine-grained materials.

- Jurisdictions should evaluate other methods for contaminated dredged material disposal such as deep water disposal, capping, stabilization and partial confinement.

- Management agencies should emphasize long-term management of CDFs following the transfer of CDFs to local authorities. Management plans need to ensure the future maintenance and safe use of the facility, and adequate monitoring of the facility relative to the intended confinement of contaminants.

- Operational procedures to promote rapid dike sealing and minimize contaminant movement should be further developed and implemented.

- The design, construction and operation of CDFs should provide assured confinement of contaminants within the facility and maximize beneficial uses of the facility relative to commercial development, recreation and/or fish and wildlife.

- Monitoring programs be implemented for harbour, tributary and connecting channel sediments sufficient to describe the levels and trends of sediment contaminants in areas subject to dredging. These data are essential to the prediction of needs for additional CDFs or alternative options for disposal of contaminated sediments.

- Thorough cost/benefit analyses be performed for selected CDFs. Such analyses should consider the relative costs for alternative disposal options for similarly contaminated sediments; the likely economic impact of not dredging the contaminated sediments; the potential value of the CDF for recreational, commercial or other uses; and the likely value derived from isolating and confining environmental contaminants.

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Extended Abstracts

The following papers were prepared in response to specific invitations from the Dredging Subcommittee of the International Joint Commission's (IJC) Water Quality Board. The authors presented these papers at the Confined Disposal Facilities Forum held May 22-24, 1985, in Toronto, Ontario. Although the Dredging Subcommittee had requested only extended abstracts, you will note that some authors have prepared full papers. For the sake of expediency the Dredging Subcommittee did not attempt to edit these papers, nor were the authors asked to edit them in order to reach more uniformity in their level of detail.

The abstracts were retyped at the IJC Great Lakes Regional Office, for common format and typeface. The Dredging Subcommittee wishes to give its sincere thanks to the authors and presenters for their generous contributions.

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CONFINED DISPOSAL FACILITIES IN THE CANADIAN GREAT LAKES

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INTRODUCTION

Historical Perspective

The disposal of contaminated dredged material in engineered confined disposal facilities (CDFs) in the Canadian Great Lakes has been practiced since the early 1970s. Until that time dredging, followed by mostly open lake disposal, was the established procedure for all types of mechanical and hydraulic dredging projects. However, with the awareness of adverse environmental impacts associated with the open water disposal of contaminated dredged material, the practice changed significantly. The emphasis shifted from 'dilution/dispersion' by open water disposal to 'isolation/confinement' in specially constructed containment facilities. The result has been a steady increase in the confinement of dredged material from 60% in the mid-70s to 85% in the early 1980s. Most of it has been contributed by an increase in the dredging of major commercial harbours during the same period. It is a well-known fact that harbours, particularly large industrialized ones, accumulate and concentrate many contaminants brought in by rivers and tributaries to significantly high levels through sedimentation. So, based on our current knowledge and understanding of pollution potentials and pathways, sound environmental practice has dictated that all contaminated material must be disposed of in engineered facilities.

The discovery of mercury in the fish of the St. Clair River and Lake St. Clair system brought into focus the problem of contamination of the Great Lakes and its bottom sediments. A complete ban was placed on fishing activities in these bodies of water. The obvious economic and social impacts of such a drastic move set the political and governmental machinery in motion to tackle this problem. Internationally, this problem and those caused by eutrophication culminated in the signing of the Great Lakes Water Quality Agreement between Canada and the United States in 1972 under the auspices of the International Joint Commission (IJC) which has supervised the 1909 Boundary Waters Treaty between the two countries.

As a first step, the IJC set up a "Pollution from Dredging Activities Group" to study the problem in the entire Great Lakes. On the Canadian side, the need to redredge the S.E. Bend Cut-Off Channel had become rather urgent. The channel had shoaled in to such an extent that the traffic eventually was restricted to one lane only, with no passing allowed. Mercury levels in the channel bottom sediment were found to be 3-5 ppm, far in excess of the allowable value of 0.3 ppm for open lake disposal. Environment Canada and the Ontario Water Resources Commission (now Ontario Ministry of Environment) would not allow open lake disposal of even a small quantity of the dredged material on an emergency basis.

The most suitable and logical land disposal site was Seaway Island, located adjacent to the S.E. Bend Cut-Off Channel and owned by the Walpole Island Band of Indians. Negotiations began with the Band for use of the island, but soon broke down because of the unreasonable monetary compensation and environmental protection demanded by the Band. Several other alternatives were then considered, the most promising of which was the creation of a containment island in Lake St. Clair for the disposal of mercury contaminated dredged material.

To study the suitability and viability of such a disposal scheme, an experimental artificial island termed 'Pilot Island' was constructed in Mitchell's Bay of Lake St. Clair. The project was also undertaken in part to support the study being conducted by the IJC Group on Dredging. The 'Island' was rectangular and had three containment bays and a settling basin. Walls were made of steel H piles with S.S.P. panels and, except for the first bay, were lined with a plastic sheet. Starting in November 1973, mercury contaminated sediments were dredged from various locations in Mitchell's Bay and disposed of on the island.

After a considerable period of consolidation, a monitoring program was initiated in 1978 to investigate the mercury concentrations and distributions into plants, soils and sediments. Although the results of the experiment proved inconclusive as to the effectiveness of the island in disposing of the mercury contaminated dredged material, it proved the viability of such a disposal concept if suitably designed and operated. The 'Pilot Island' was eventually removed in 1981 and the material disposed of behind a containment wall on the nearby shoreline. In 1975 preliminary designs were prepared to build a similar island for the containment of up to 3/4 million m^3 dredged material from the S.E. Bend Cut-Off Channel. Excessive costs and logistic problems forced the plan to be terminated before construction began. The S.E.B. Channel dredged material was eventually disposed of in three containment facilities constructed along the Channel on the Seaway Island shoreline. This was possible only after a series of meetings and negotiations with the Band, including a substantial royalty and a 20-year property lease.

Nonetheless, it marked the beginning of the era of confined disposal facilities in the Canadian Great Lakes.

ENVIRONMENTAL PROTECTION REQUIREMENTS

No single act or legislation specifically regulates dredging and disposal activities and construction and operation of disposal facilities in the Canadian Great Lakes. In the absence of specific legislation, acts pertaining to introduction of deleterious substances and activities harmful to water quality, biota fish and other aquatic life have been used as regulatory tools. A brief description of such federal and provincial acts and their relevance to CDFs is provided below:

Federal

- Navigable Water Protection Act (NWPA): This Act prohibits the building or placement of any work in, upon, over, under, through, or across navigable waters without approval of Transport Canada. Since most of our disposal facilities are located adjacent to navigable waters, this Act has special relevance to siting of facilities.

- Fisheries Act: Pollution control clauses of this Act prohibit deposition and discharge of contaminants into waterbodies. This enjoins that all effluents from CDFs meet applicable water quality criteria.

- Migratory Birds Convention Act: This Act prohibits deposition of material deleterious to aquatic environments frequented by migratory birds. The requirement to protect and adequately cover deposited contaminated material emanates from provisions of this Act.

Apart from the Acts listed above, all Federal undertakings including CDF projects are evaluated under the umbrella Environmental Assessment and Review Process (EARP) originally established by a Cabinet directive in 1973. As a review and screening tool, it enables a broad initial assessment of a proposed CDF and helps identify and possibly mitigate environmental concerns of a general nature at an early stage. Amendments made to EARP in 1977 and 1984 emphasize inclusion of public participation/public consultation aspects in the environmental review process. This should help focus attention at an early stage to seek public input into decisions regarding siting, construction and operation of CDFs in sensitive areas.

Provincial

Due to its jurisdictional control over water quality and natural resources, the Province of Ontario is actively involved in the regulation of CDFs in the Canadian Great Lakes. It administers the pollution control section of the Fisheries Act on behalf of the Federal Government and is also a major participant in the promulgation of the Great Lakes Water Quality Agreement between Canada and the United States.

The Ontario Ministry of Environment guidelines, 'Evaluating Construction Activities Impacting on Water Resources (1976),' in fact are the only comprehensive set of guidelines available for assessment of marine construction activities in the Canadian Great Lakes. Apart from introducing bulk chemical characterization criteria, MOE guidelines also specify fundamental environmental protection requirements for CDFs. They provide a list of factors to be considered during each stage of CDFs such as site selection, capacity consideration, design and construction, effluent quality and operation and maintenance. Although site-specific considerations determine the most appropriate design and modus operandi for a CDF at a given location, MOE requires that the following basic criteria be met for each facility:

1) Dyke structures be of adequate strength to contain dredged material under forces of lateral pressure, seepage and erosion.

2) Provide maximum retention of solids and contaminants within the facility. The quality and quantity of any supernatant to adjacent watercourses and surroundings meet all applicable standards.

3) Native subsoils be of suitable quality for containment of contaminants including protection of groundwater quality.

SOME LONG-TERM CDFs

Many of the CDFs constructed would fall into short-term or one-time use categories. This is particularly true for small craft harbour locations which require rather infrequent dredging and therefore do not need multi-use facilities for disposal of contaminated dredged material. In case of major industrial/commercial harbours, which have a predominance of contaminated sediments, the need for long-term CDFs is obvious. The following is a brief description in chronological order of some of the major CDFs with which we have been associated in construction or usage, or both.

Hamilton-Bayside Disposal Facility (BDF)

Hamilton Harbour sediments are known to be among the most polluted in the Great Lakes. Mean concentration values for almost all contaminants are orders of magnitude in excess of MOE guidelines for open lake disposal. Environmental degradation is so severe that the harbour is designated by the IJC as one of the Class "A" Areas of Concern.

In recognition of this, BDF was the first major long-term CDF in Ontario constructed by the Hamilton Harbour Commission in 1970. Total estimated capacity of the facility is approximately three million m^3. To date almost two-thirds of the site has been filled and is ready for industrial complex development. Remaining areas have been divided into cells to be filled in stages and to provide better retention for fine particles in the hydraulically pumped dredged slurry. For mechanical dredging projects, the facility's perimeter berm contains an opening which allows scows to bottom dump within the facility. Results of environmental monitoring have shown no evidence of particulate loss from the facility in hydraulic and mechanical modes of operation.

S.E.B. Cut-Off Channel Disposal Facilities

Maintenance dredging of the S.E.B. Channel was not necessary until 1970 due to overdredging at the time of its original construction in 1960 by the U.S. Army Corps and persistent high water levels. As discussed earlier, discovery of mercury contamination of the St. Clair River and the Lake St. Clair made disposal of the dredged material one of the most difficult and arduous undertakings.

The search for suitable disposal sites spanned over several years, which included extensive property rights negotiations with the Walpole Island Band of Indians, owner of the islands on both sides of the Channel. Agreements and environmental approvals were finally obtained and construction of the facilities started in the fall of 1977.

The original disposal facility consisted of three independent confinement areas located equidistant along the length of the 10 km channel on the shoreline of Seaway Island. Each facility consisted of one large disposal cell with an adjoining cell for decantation of supernatant overflow from the main cell for hydraulic dredging projects. All three disposal areas are now full to capacity and contain approximately 500,000 m^3 (this includes the filling of the decant cells) of dredged material and the total cost including construction, dredging and royalties is approximately $8.5 million.

Comprehensive environmental monitoring was carried out throughout construction and use of the facilities in order to detect changes in mercury contamination due to disposal activities. The annual monitoring reports indicate no discernable increase in the mercury content of both terrestial and aquatic flora and fauna as a result of dredging and disposal operations.

Thunder Bay - Mission Bay Disposal Facility (MBDF)

Until the early 1970s all material dredged from the Thunder Bay Harbour, its shipping lanes and Kam-Mission River Systems was deposited in Lake Superior in various deep water disposal areas. Unacceptably high concentrations of mercury and other trace metals and contaminants associated with pulp and paper were discovered in the bottom sediments. A Task Force was instituted in 1975 to tackle this problem, and consisted of members from Public Works Canada (PWC), federal, provincial and local environmental agencies, City of Thunder Bay and the Lakehead Harbour Commission.

The Task Force recommended after lengthy deliverations that a long-term disposal facility be constructed in the Mission Bay area. PWC retained a consultant to implement the Task Force recommendation; planning and design work started in 1977, while construction began in 1978.

The facility consists of a perimeter berm rock dyke enclosing a reservoir cell and seven interior cells constructed in stages as the need arises. Dredged material from project sites is transported by dump-scows to the facility and dumped into an outer reservoir cell. A silt curtain has been placed across the main entrance to the facility and is only open to permit the scow dumping operation in the reservoir cell. Once the reservoir cell is partially filled the material is then rehandled by means of hydraulic cutter suction dredge into one of the interior cells for permanent disposal. The facility has a final design capacity of five million m^3 and the total estimated cost of the facility is approximately $13.2 million. To date only four cells have been constructed, of which two cells are almost filled to capacity.

The Task Force report also required that an environmental monitoring program be implemented to assess the overall performance of the facility in containing the polluted dredged material, particularly during dumping and rehandling operations. The results of monitoring since the construction and initial use of the facility in 1980 generally have been encouraging with regard to performance and have provided useful criteria for its proper operation.

Oshawa Disposal Facility

The most recent of our long-term facilities was built in 1981-82 at a total cost of $0.95 million, with a total capacity of 90,000 m^3. It is used mostly to contain highly contaminated sediments in the inner areas of Oshawa Harbour.

The facility consists of one main disposal cell and an adjoining decant cell with overflow weir provisions in both cells. Its design is somewhat different in view of the 4-6 tonne armour stone protection provided on the lake side, which is exposed to high waves and severe ice conditions during winter. The main berm of 100-450 mm core stone rests on a 1500 mm thick stone mattress due to poor subsoil conditions.

The facility was designed for a five-year life cycle but only 35,000 m^3 of polluted and marginally polluted material has been placed in the facility to date by hydraulic and mechanical means.

CURRENT STATUS AND FUTURE TRENDS

The following table depicts the construction costs for the three disposal facilities which were constructed by PWC.

TABLE 1.

LOCATION	YEAR	DESIGN CAPACITY	LIFE CYCLE	CAPITAL CONSTRUCTION COSTS	PRIMARY POLLUTANTS
South-East Bend	1977-79	350,000 m^3	Completed	$ 3.9 M	Hg
Thunder Bay	1978-79	5,000,000 m^3	20-25 Years	$13.0 M	PCBs, Hg, Pb, Cd
Oshawa	1981-82	90,000 m^3	5 Years	$ 0.95M	PCBs

It is obvious that the confinement of polluted and sometimes even marginally polluted material has been carried out at a substantial monetary and human resources cost. The prospect of building long-term CDFs in Ontario is not promising in view of the prevailing economic climate. The following site-related problems would be encountered in constructing any new facility:

- Scarcity of Crown-owned sites for siting CDFs in the vicinity and within easy and economic access of major industrial/commercial harbours.

- Increasing difficulties faced in using upland sites. Stringent environmental protection requirements are in place for handling and transporting contaminated dredged material.

- Reluctance of private property owners to offer their properties for disposal of contaminated dredged material because of the complicated approval processes involved.

Fortunately, a pressing need does not now exist for a new facility at any major ports and harbours in Ontario. The MBDF in Thunder Bay should suffice for a longer period than the originally planned 20-year life cycle because of a substantial drop in anticipated dredging volumes. The mercury levels in the S.E.B. Cut-Off Channel have registered a marked decline over the years. Most future dredgings from this location may qualify for open lake disposal and under less restrictive conditions. In Hamilton's BDF the remaining capacity should be sufficient for dredging needs for the near future. In Oshawa, actual dredged volumes requiring confinement have remained well below the anticipated 20,000 m^3 per annum.

Although confinement in engineered disposal facilities removes polluted sediments from the active aquatic environment, long-term impacts of such facilities on adjacent water bodies, subsoils, groundwater, and flora and fauna remains to be determined. An ideal but unfortunately unrealistic solution to the problem would be the elimination of all point and nonpoint sources of sediment contamination. In terms of more realistic and short-term goals, however, efforts should be directed to better understand and define toxicity, bioaccumulation potential of various contaminants present in the sediments. This would enable development of innovative, imaginative and less costly techniques for contaminated dredged material disposal. The 'capping' and 'partial confinement' of material in open lake environments constitute important initial steps in that direction, provided they can be carried out without severely taxing the already fragile ecological balance and assimilative capacity of the Great Lakes.

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CONFINED DISPOSAL PROGRAM FOR POLLUTED MAINTENANCE DREDGING IN THE GREAT LAKES

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INTRODUCTION

As a consequence of rapid industrial and urban growth in areas adjoining the Great Lakes, concern developed for any adverse effects that open lake disposal of dredged material might have on water quality and lake ecology. As a result, Congress requested the Corps of Engineers in 1966 to conduct an investigation into the feasibility of using alternative methods of disposal at selected harbors on the Great Lakes. Results of the investigation indicated that additional study was needed and that, in the meantime, containment of polluted dredged material would be a step in the direction of improving water quality.

From 1968 through 1970 the U.S. Environmental Protection Agency took bottom sediment samples in all the navigation channels and harbors in the Great Lakes. The bottom sediments of 77 out of 129 harbors were classified as unsuitable for open lake disposal.

In 1970, Section 123 of PL 91-611 of the Rivers and Harbor Act authorized the Corps to construct, operate and maintain confined disposal facilities (CDFs) to contain polluted maintenance dredging for ten years subsequent to construction. Except for the Great Lakes connecting channels, local participation was required. For connecting channels projects, the Corps would construct, operate and maintain the facility; for projects involving local cooperation, local interest must pay 25% of the construction costs unless they are actively pursuing or have developed an EPA-approved plan to clean up the sources of pollution. If local interests comply, the government pays 100% of the costs of construction.

THE CDF PROGRAM

Currently, 37 U.S. federal projects require CDFs (down from 77 originally classified as polluted). This will result in the construction of 29 CDFs; 25 have been constructed.

The total federal cost for the CDF program, when completed, is estimated at $340 million. Through FY/1984 funding has amounted to $292 million. FY/1985 funding will be $12 million, which will put us at 90% completion for the program.

DESIGN CONSIDERATION

The normal method of containment is to provide the dikes on public lands or bottom lands high enough and encompassing an area large enough to contain ten years of dredged material together with any backlog material that may have accumulated. Capacity for private permitted dredging is provided at cost.

Dike facilities typically are constructed of a gravel core covered by armor stone. The gravel core is intended to restrict the movement of solids and their associated contaminants, while the armor stone provides resistance against erosion from wave action. Where appropriate, containment areas are provided with a mooring facility for the dredge pumpout facilities. A weir with an oil skimmer or a filter system, if needed, is provided to control outflow from the site so that applicable water quality standards are not violated.

Site selection is the biggest problem in the dike construction program. It is generally related to environmental concerns since most of the dike disposal area projects are, for economic reasons, located in or near the water, close to dredging areas. Potential marine sites are easy to identify since they are, for the most part, in public ownership. Upland sites are preferred for environmental reasons, but they are hard to find, access is difficult, and they can be expensive. However, as our experience and that of other concerned agencies grows, trade-offs have been developed to facilitate the site selection process.

All concerned agencies are involved early in site selection through a site selection committee composed of representatives from the U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, the local states' Department of Natural Resources, and the Corps of Engineers. Public workshops are used extensively to guide the selection process and obtain local acceptance of the selection decision.

Incidental Benefits

Attempts are made to maximize beneficial uses of dredge material through marsh reclamation, recreational uses, wildlife enhancement and marina development. Some of these beneficial uses are demonstrated at the following harbors:

At Frankfort Harbor, Michigan we are creating a land mass for a future marina and land reclamation. The prime disposal area will be state forest land approximately 15 miles from the harbor. The soil is sandy and unproductive; spreading and tilling the nutrient-rich dredged material into the native sand soil is expected to result in lush growths of vegetation and ultimately high-quality habitat for wildlife. Since the dredged material will be trucked, offloading facilities have been built on the waterfront (clam and barge operation). The area was designed so that, upon completion of the ten-year maintenance period, it could be incorporated into the city's planned, contiguous marine expansion and would include tennis courts, picnic areas and other passive recreation facilities.

At Clinton River, Michigan we are creating a recreation area. Land for the disposal facility is adjacent to and was originally part of Selfridge Air National Guard Base. It was also in the middle of a residential area, was undeveloped and provided no beneficial services to the air base or to the community. Through coordination with the community, the area is being designed to serve the needs of navigation and community recreation.

Berms and flat (8-on-1) side slopes on the dikes and landscaping will minimize visual impact and provide the basis for recreation development to be carried out by the State of Michigan after the facility is filled. CDFs in Holland Harbor, Michigan and Grand Haven Harbor, Michigan are similar, in that they would also serve as future recreation areas through reclamation of land which in the original state served no useful public purpose (they were dumps). The Clinton River project is in the design analysis stage, preceding plans and specifications.

At Bolles Harbor, Michigan we are providing a State of Michigan Marina expansion and camping opportunities with the construction of a CDF that extends 1,800 feet from the shoreline into Lake Erie. The rock armour on the dikes also provides an excellent fisheries habitat. Construction is completed at this site.

At Pointe Mouille, Michigan a 3-1/2 mile long CDF will replace an eroded natural barrier reef that had protected a 3,500 acre marsh. It will also provide enhanced future hunting, fishing, parking, viewing and boat launching opportunities on and adjacent to the CDF itself. With the demise of the original barrier reef, wave attack from Lake Erie had virtually destroyed this valuable marsh on one of the nation's major north/south wildfowl flyways.

The State of Michigan is now constructing a cross dike system behind the CDF so that the four marsh areas may be intensively managed. Construction is completed here. Water levels in these areas will be varied so that diverse habitat can develope. Lowering the water level in the two areas immediately behind the CDF will promote immediate marsh development in the area most ravaged by wave action. All agricultural units will provide varied upland feeding areas. An interpretive center will be developed for public use/information dissemination on the marsh development and use in progress and educational programs on the ecological aspects of the area.

At Monroe, Michigan we are developing a scenic overlook, parking, camping and recreation area, and habitat creation for both upland and marine life. This site is located at Sterling State Park about two miles from the harbor. Since the CDF will be armored with cover stone facing Lake Erie, it will also provide an excellent fisheries habitat. This was enhanced by taking surplus stone from site clearing operations and using it to create rock reefs extending lakeward from the CDF.

After the CDF is filled, it will be developed by the state as a natural area with paths and nature interpretive facilities. Since the top elevation of the CDF will be 24 feet above Lake Erie low water datum, it will also serve as a scenic overlook on Lake Erie. Surplus excavation also has been used to raise campgrounds frequently flooded by lake seiches and to reinforce dikes in a managed marsh area. Construction is scheduled for completion in July 1986.

Our CDF at Holland, Michigan is a good example of site adaptation. The local community is proud of the extensive flower beds and windmills - both popular tourist attractions.

Our two CDF sites constructed for the project blend in using this program. The primary site was designed to receive dredge material pumped directly from the dredge. After the material dries, it is trucked to the second site for park development until construction is complete.

At Green Bay, Wisconsin a ten-year disposal plan was established and a confined disposal facility constructed. It was found later that certain factors, such as overdepth and back log, were incorrecty determined during original design and resulted in a deficient dike capacity. Therefore, we are now proposing to build a new dike to hold this deficient amount, estimated to be approximately 3.7 million cubic yards.

Moving across the Great Lakes to Buffalo, the CDF is built using an existing breakwater as one leg and ties into the shoreline alongside. This addition provides reduced cost and a vital stretch of shoreline is protected from erosion.

At Erie, Pennsylvania we again used a breakwater for one side of the CDF and upland for the second side. Easy access to the area is provided with the Federal Navigation Channel alongside the CDF.

At Cleveland Harbor, a series of CDFs have been used over the years. A site adjacent to the Burke Lakefront Airport has been used and, when filled, will provide land to expand the airport.

Area #14 at Cleveland is currently being filled and will provide added park space in an urban area in dire need of open space.

At Lorain Harbor, we used the outer breakwater and the efficiency of a semicircle to provide the needed capacity. Huron Harbor used a similar design against the outer breakwater.

At the end of Lake Erie at Toledo Harbor, the CDF is located out in Maumee Bay. When filled it will provide much needed space for the port authority. The space between our CDF and the shore will be filled by the port authority to complete this expansion of the port of Toledo.

Our CDF for the Saginaw River is a kidney-shaped island in Saginaw Bay. Concern for the visual obstruction had to be satisfied before we could use this site.

Moving to Lake Michigan, at Manitowoc, our CDF here provides protection for a small boat harbor inshore of the area.

At Milwaukee Harbor, we again used a harbor breakwater as one leg of the CDF. This also provides a platform for the dredge material to be unloaded. A similar area is provided at Kenosha, again using the harbor breakwater as one leg of the CDF.

One of the most unusual CDFs on the Great Lakes is located in Duluth-Superior Harbor. This area has no discharge of water back to the harbor. Evaporation is the only means to dry out the area.

Our newest CDF is located in Chicago adjacent to the port authority's lake front terminal. When filled it will provide additional storage space for the terminal.

Some of the design and operational considerations of our CDFs include: CDF dikes are generally trapezoidal in section with sufficient top width for maintenance vehicles. Armor stone is provided in areas subject to wave attack. Upland CDFs are simply vegetated for erosion control. Dikes are constructed to prevent seepage and escape of contaminants into the environment. To this end, impervious dike cores can be employed, or the CDF can be lined with an enduring material that accomplishes the same purpose.

Most CDFs for deep water harbors were designed to accommodate use by Corps of Engineers hopper dredges. Private industry now has several such dredges on the Great Lakes, and the Corps dredges have been mothballed. A pipeline is used to distribute the dredge material around the facility and the pipe is located generally toward the center of the CDF for better distribution of the dredge material.

Overflow weirs and oil skimmers are used to permit water to return to the waterway. In many areas a short section of corrugated metal pipe (CMP) with an outlet that passes through the dike into the lake is used. The weir boards can be set at various elevations to control settling time of fine soil particles. The CMP outlet then works like a drop manhole.

Filter cells are used where there is a concern for quality of effluent from the CDF. For example, Monroe (Sterling State Park) is near a swimming beach. The filter medium is a progressively finer gradation as the effluent path approaches the weep holes in the steel sheet piling. Holes are covered with plastic filters to prevent loss of the finer graded filter medium.

Cutter head dredges can also be used where the CDFs are close enough to the dredging to make it practical. However, this arrangement has been the exception rather than the rule. Some sites are not readily accessible to marine plant and pipelines and booster stations are not practical either because of the distances involved or environmental problems. In these situations, trucks become a part of the transportation system. Depending on the nature of the dredged material, the material can be offloaded from barges directly to trucks. However, in situations where the dredge material is so soft and so saturated that it must be dewatered before trucking, interim sites are employed. These interim sites are designed to hold enough material for one season of dredging.

Progress has been made and we have a better understanding of the effects of open lake disposal of contaminated dredge material. However, some areas simply are not cleaning up that quickly - Cleveland Harbor on Lake Erie and the Rouge and Detroit Rivers in Michigan may take longer. In these cases, CDF construction responsibilities would revert to those defined in the original project authorization upon completion of the ten-year program. An expensive dredging program, in terms of disposal, is a problem that has caused growing concern. Special legislation may be the only solution that can keep these harbors alive because of the expense of producing a CDF with a substantial share at local cost. As part of that scenario, we may have to demonstrate that the Great Lakes again deserve special consideration for federal funding, as was the case with PL 91-611.

CONCLUSION

The dike disposal program has been with us since 1970, but progress has been made only through preservance and expenditure of considerable effort. A big part of the problem stems from the fact that the marine environment is involved, it is very sensitive and a matter of great local concern. Intensive activity through the Site Selection Committee composed of the local Department of Natural Resources, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency and the Corps is required to hammer out a solution. Local workshops are also employed.

The local sponsor's ability to pursue the matter also varies greatly and has a proportional effect on progress. Some communities do not have the resources to pursue the matter effectively. However, some are complete with talent and funds to make great strides even in the face of substantial difficulty. In some cases, the desire to participate does not surface until the shoaling occurs; resulting in an emergency situation that only produces a partial solution.

In some cases, the nature of the pollution is so unique that progress cannot occur until decisions are made on the best procedures for dredging and disposal. This is based on concerns that conventional means will not be satisfactory.

Facing up to these problems has produced some unique solutions. Pointe Mouille and Sterling Stage Park are real success stories in dealing with environmental problems. Green Bay, Wisconsin has set up a special committee that meets monthly to help produce a solution for an environmentally sensitive area which has some of the most heavily contaminated dredge material in the lakes. Sheboygan Harbor is heavily contaminated with PCBs. A bioassessment will be needed before we can ever establish the scope of the dredging there.

Section 123 of PL 91-611 contemplated a ten-year program. It was assumed that the sources of pollution would be cleaned up by that time. Thirty-three (33) Great Lakes harbors have, in fact, cleaned up to the point where they can again be considered suitable for open lake disposal.

SELECTED CASE STUDIES TO ILLUSTRATE ENVIRONMENTAL CONSIDERATIONS IN PLANNING CONFINED DISPOSAL FACILITIES WITHIN UNITED STATES WATERS: A REVIEW OF ANALYSIS AND DOCUMENTATION REQUIREMENTS

Philip E. Berkeley and William F. MacDonald
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The Buffalo District, U.S. Army Corps of Engineers currently has lakeshore confined disposal facilities (CDFs) at six harbors on Lake Erie. The CDFs were constructed, primarily in the 1970s, in response to problems with open lake disposal of polluted dredged materials. The six CDFs located at Buffalo Harbor, New York; Erie Harbor, Pennsylvania; Lorain Harbor, Ohio; Toledo Harbor, Ohio; Huron Harbor, Ohio; and Cleveland Harbor, Ohio, are generally connected to harbor structures (breakwaters and jetties), are usually of stone construction and have an anticipated capacity of ten years harbor maintenance dredging.

Before construction of any new CDFs, it is necessary to chemically and biologically test the dredged materials, consider alternative disposal methods and evaluate their economic, environmental and technical feasibility according to the 1983 Principles and Guidelines published by the U.S. Water Resources Council. In addition, the proposed CDF must be reviewed under a number of environmental compliance statutes and guidelines including the National Environmental Policy Act, which requires that an Environmental Impact Statement be prepared for most Corps projects. Other review requirements include the Clean Water Act, Fish and Wildlife Coordination Act, Endangered Species Act, Coastal Zone Management Act, National Historic Preservation Act, and others.

The various environmental review requirements are applicable both to Corps of Engineers Civil Works projects and to private and/or government projects where the Corps has regulatory responsibility under Section 404 of the Clean Water Act and Section 10 of the River and Harbor Act (issues permits).

J. B. Wolff and Associates' "The Harbor" development, in Sandusky, Ohio is an example of an innovative approach to confined dredged material disposal and wetland development. Over 500,000 cubic yards of moderately polluted dredged material was used to construct a 96-acre wetland. Ultimately the confined disposal facility will serve as a valuable wetland resource as well as a nature study and research area.

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INTERAGENCY AND PUBLIC INVOLVEMENT IN SITING CONFINED DISPOSAL FACILITIES

Paul Mohrhardt
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Following authorization of the Confined Disposal Program in 1970, the Chicago District experienced initial success in obtaining sites for confined disposal facilities. However, as sampling and analysis of sediments became more sophisticated and state and local technical expertise increased, progress ceased, with rejection of some previously selected sites.

An analysis of the program and techniques being used to evaluate and select disposal plans identified several problem areas, including certain local cooperation requirements included in the authorizing legislation. Except for the connecting channels, all Section 123 disposal facilities require a local sponsor to furnish rights of way. Potential sponsors in the States of Wisconsin, Illinois, and Wisconsin are limited to local governmental entities such as municipalities, counties, or small port commissions with limited jurisdictions and financial resources. Sponsorship, therefore, tended to limit sites which could be considered for implementation. In addition to sponsor acceptance, site concurrence by other federal agencies and their counterpart state agencies are required. The site selection process used at the time consisted of primary site coordination between the Corps of Engineers and the tentative local sponsor, with other agency and public review coordinated through distribution of a draft Environmental Impact Statement prepared after site selection. Views of other governmental agencies and the public at large were, therefore, marginally considered during site selection, resulting in potential rejection of the chosen site and reinitiation of a new site selection.

A new procedure was formulated which included and involved all interested federal, state and local governmental agencies to provide a forum for discussion and negotiation between the diverse interests of these entities. This resulted in development of a diverse range of potential alternatives, with evaluation iterations performed on the potential alternatives. Public interest groups were invited, if such a desire was expressed, to participate in the process.

The net result of full participation of this type was an extension of time required for site selection, but usually unanimous concurrence, or at least acceptance of a CDF site with assurance that the site would not be rejected during later reviews. A secondary benefit was the early identification of other agency and public needs and concerns in relation to the dredging and disposal actions at the specific harbors.

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PUBLIC PERCEPTIONS REGARDING CDFs AND THEIR INFLUENCE IN SITING DECISIONS FOR TORONTO HARBOUR

Brenda Lee
Toronto, Ontario

By anybody's standards, the political and jurisdictional environment on the Toronto waterfront is complex; it is difficult for an outsider to understand and it is even more difficult for an insider to operate within. Two strategies for survival in this jurisdictionally dense and politically sensitive environment have been to use the considerable ambiguity which exists in jurisdiction mandate and regulatory control as an adjustment lever, and to carefully manage the generation and release of information. It is not surprising then that the perception of those outside this environment of the key issues at stake and the possibilities for resolution are different from those of the participants themselves. This paper briefly outlines the views of those "outside" the major issues of lakefill quality and integrated waterfront planning and clarifies some of the reasons for the differing points of view. It then makes several suggestions in light of these differences about the potential role of the various public groups in future siting and management of confined disposal facilities.

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SITE SELECTION, DESIGN AND CONSTRUCTION EXPERIENCES WITH CDFs IN UNITED STATES WATER OF THE UPPER GREAT LAKES

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Dredging of navigable waters in the Great Lakes dates back to the early 19th century. Dredging was usually limited to removal of material deposited at the mouth of rivers by littoral drift and the delta building action of rivers. Disposal of dredge material, which was once only incidental to construction and maintenance, has become a major effort. More often than not, prior to 1970, dredge material was simply deposited in open water sites with such decisions based primarily on economic considerations. Approximately two-thirds of the sediments dredged during that period were open lake dumped. Only three confined disposal areas were used in connection with maintenance in the upper Great Lakes. Another consequence of rapid industrial and urban growth in areas adjoining the waterways is the concern for any adverse effects that open lake disposal of dredged material might have on water quality and ecology.

From 1968-1970 the EPA took bottom sediment samples in all of navigation projects on the Great Lakes. Subsequently, the bottom sediments of 77 out of 129 harbors were classified as unsuitable for open lake disposal. In 1970, Congress passed PL 91-611. Section 123 of that law authorized the Corps of Engineers to construct, operate and maintain confined disposal facilities (CDFs). The usual method of containment is to provide dikes on public lands high enough and encompassing areas large enough to contain ten years of maintenance dredged material together with any backlog material that may have accumulated. The dike facilities are typically constructed of a gravel core that is covered by armor stone. The gravel core is intended to restrict the movement of suspended solids and their associated contaminants, while the armor stone provides resistance against erosion from wave action. When appropriate, containment facilities are provided with a mooring facility for the dredge and pile bents to support the pumpout pipe. A weir with an oil skimmer or, of needed, a filter system is provided to control outflow from the site so that applicable water quality standards are not violated.

Site selection is the biggest problem in the dike disposal program and generally related to environmental concerns. This basically stems from the fact that most of the dike disposal area projects are, for economic reasons, located in the water close to dredging areas. However, as our experience and that of the concerned agencies grows, tradeoffs have developed to facilitate the site selection process. Some of the beneficial uses that have grown out of the program are:

1) marine and land reclamation (Frankfort, Michigan);
2) recreation area (Clinton River, Michigan);
3) habitat creation, fishing, scenic view, camping and recreation area (Monroe, Michigan);
4) State of Michigan marine expansion (Bolles Harbor, Michigan in Lake Erie); and
5) hunting, fishing, and marsh reclamation (Pointe Mouille, Michigan).

The completed facility at Pointe Mouille, Michigan, is about 2-1/2 miles long by 3/4 mile wide, covering 685 acres. It is sized to contain about 18-1/2 million cubic yards of dredge material. Construction was carried out in two phases.

The confined disposal facility (CDF) dikes are trapezoid in section with sufficient top width, 12 feet to provide access for maintenance vehicles. Armor stone is provided on all sides, including the interior. A causeway was constructed in the south end for construction and maintenance access as well as pollution abatement. The facility, located in the northwest corner of Lake Erie, is sited in water depths ranging from two to nine feet below International Great Lakes Datum (IGLD) along the lakeward face of the structure. Depths in the lee of the structure are one to two feet.

Lake Erie is about 240 miles long and the structure is only exposed to minimal fetches of 130,000 feet, 122,500 feet from south 45 degree east and the south respectively, due to intervening land masses and islands. The design water surface is the sum of the 20-year monthly mean of +4.3 feet and short period fluctuations of +3 feet. Wave heights are of about a 20-year frequency so that the combined wave and water level frequency is about 400 years.

Fifty-three borings were taken in the course of designing the CDF. It was found that the foundations are generally weak. To avoid uncertainties in attempting to "mud wave" weak soil under the dike during construction, to assure a safety factor of at least 1.3 and to reduce errors in dike quantity estimates, the weak soil under most of the dikes was excavated to a point where an estimated stability safety factor of 1.3 would be reached. This involved excavation of up to 12 feet below the existing bottom of some regions of the dike.

Phase I dikes were to be constructed using certain categories of clay excavated from the lake bottom adjacent to the CDF. Due to construction difficulties, this approach was abandoned. A nearby upland source was located and the remainder of the dike material was trucked in. The Phase II dike design was based on the use of prepared limestone in lieu of clay. Ease of placement was assured and the limestone is lighter which resulted in some economies in quantities because of the soft lake bottom. In addition, compaction is readily achieved and there is better water quality during construction due to reduced turbidity.

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PROCEDURES FOR PREDICTING EFFLUENT QUALITY AND STORAGE CAPACITY AS DESIGN CRITERIA FOR CONFINED DISPOSAL FACILITIES

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Disposal of dredged material in diked containment areas is an alternative commonly used when the sediments to be dredged are deemed unsuitable for open water disposal. Since this disposal alternative involves the placement of dredged material in human-made structures, considerable attention from an engineering standpoint is required. Also, the intent of the areas is to provide retention of contaminants within the structures to the greatest possible degree. This requires that the areas be designed to properly retain the dredged material and associated contaminants during and following the disposal operation. This presentation will provide an overview of state-of-the-art procedures for designing dredged material containment areas from the standpoint of effluent quality and storage capacity.

Procedures are available for contaminant area design for retention of suspended solids based on solids removal through gravity sedimentation (Palermo, Montgomery and Poindexter, 1978). The procedures determine the required surface area or residence time to accommodate continuous hydraulic placement of dredged material. The storage volume required for a disposal operation is also determined considering the changes in volume occurring during filling. Laboratory settling tests provide needed data for use in the design procedures. Guidance for chemical clarification for removal of additional suspended solids is also available if effluent standards cannot be met by gravity settling processes alone (Schroeder, 1983). Laboratory tests are described for screening potential polymers and estimating dosage and mixing requirements.

A technique for predicting the chemical quality of effluent discharged from containment areas is presented (Palermo, 1985). The technique relies on a modified elutriate laboratory procedure which simulates contaminant release under confined disposal conditions and reflects sedimentation behavior of dredged material, residence time of the containment area, and the geochemical environment of the ponded water during active disposal operations. The acceptability of a proposed disposal operation can be evaluated by comparing the predicted contaminant concentrations in the effluent with applicable water quality standards.

Management activities are described which improve efficiency and prolong the useful life of containment areas. These include judicious location of inflow points with respect to outlet structures, placement of thin lifts, management of ponded water, and active dewatering operations. Procedures for predicting the long-term storage capacity of containment areas are also presented. These procedures rely on consolidation tests and use of computer models for predicting the consolidation and dewatering behavior of multiple lifts of dredge material placed in the sites over extended time periods.

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THE COST OF CONSTRUCTION, OPERATION AND MAINTENANCE OF THE CONFINED DISPOSAL FACILITY AT THUNDER BAY, ONTARIO

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BACKGROUND

The Port of Thunder Bay is the head of navigation on the Canadian side of the Great Lakes. The Port developed as the harbours of two separate cities, Fort William and Port Arthur, which were amalgamated in 1970 into the City of Thunder Bay. The Fort William Harbour comprises a delta formation with three channels known as the Kaministiquia, Mission and McKellar Rivers together with developments founded on the Kaministiquia River above the delta for a distance of approximately 5,000 metres, or three miles. The Port Arthur Harbour is entirely different, as a continuous basin along the lake frontage protected by breakwaters.

Until the early 1970s, all dredged sediments removed from the navigation channels and basins in the Port of Thunder Bay were deposited in various deep water areas of Thunder Bay. Little consideration was given to the quality of sediments being removed and no special efforts were made to control the dispersal of such materials either during dredging or during disposal operations. Concern over water quality degradation of Thunder Bay due to contaminants contained in the sediments dredged from the Lower Kaministiquia River Basin resulted in a ruling by the former Ontario Water Resources Commission that these sediments could no longer be given open water disposal.

Due to the extent of dredging activities in the Port, a practical and environmentally sound alternative for disposal of these contaminated dredged sediments was required.

TASK FORCE

In 1975, a task force was established at Thunder Bay to find a long-term solution for disposal of these sediments. The Task Force was formed under the chairmanship of Public Works Canada with members from other government departments and agencies at all levels directly concerned with matters affecting the Port of Thunder Bay.

The Task Force concluded that disposal should occur via a dredge disposal facility which would contain the contaminated sediments, would be functional over years and which could be incorporated into a green belt or recreational land use plan. In the selection of such a facility, a number of engineering, socioeconomic and environmental aspects had to be satisfied.

A site at Mission Bay was chosen for the facility over four others, due to its proximity to the majority of dredging areas and because of its accessibility by both land and water. The site had not been utilized recreationally, was hazardous to boating, and as a wetland area experienced limited waterfowl use - predominately feeding and resting and no significant observed nesting. Some breakwater structures were already in place and the shallowness of Mission Bay would simplify berm construction.

Treasury Board Approval to proceed with construction was given July 14, 1977.

CONSTRUCTION

The facility as constructed consists of a perimeter berm, an interior reservoir cell to accommodate temporary storage of contaminated dredge spoils, and four interior containment cells for permanent storage of the rehandled dredge spoils. When the four interior containment cells are filled, three cells will be constructed in the reservoir to allow the facility to become filled to capacity. (To further satisfy environmental concerns, a silt curtain was installed at the outshore end of the perimeter berm which allows access to the reservoir cell for dumping contaminated spoils and serves to maintain a closed system while hydraulic rehandling takes place within the cell.)

The perimeter and interior cells were constructed of granular base material designed to act as a natural filter to prevent pollutants from reaching the lake. The main breakwater fronting the reservoir cell was rock berm construction fitted with a filter fabric (Terrafix 1600) of proven filtering capability.

Construction was carried out in two stages:

Stage I. Access and connecting berm - Comprised a north and south access including a bridge connecting the facility with land access from adjacent Chippewa Park. Cost of construction for Stage I was $735,000.

Stage II. Perimeter berm and breakwater - Involved construction of the perimeter berm and the protective outshore breakwater at the lakeside end, the construction of the first two containment cells, and the silt curtain. Cost of construction for Stage II was $4,050,000. In 1983, containment cell #3 was constructed at a cost of $219,000 and in 1984, cell #4 was constructed at a cost of $330,000. The total capital expenditure to date at the facility is $5.4 million. To date there have been three rehandling operations of contaminated materials from the reservoir into permanent containment. Further rehandling is scheduled for 1985.

FIRST REHANDLING OPERATION

Upon completion of the first two stages of construction, the facility went into service. In June 1981, the first contract for the rehandling of contaminated dredge spoil from the reservoir cell into containment cell #1 immediately adjacent, was awarded. A total of 173,000 cubic metres of deposited spoil and native bottom material was rehandled with a 16" hydraulic cutter suction dredge at a total cost of $566,000.

Leakage problems through the perimeter berm in cell #1 were encountered when discharged material in the cell built up in the deeper end and the finer silts flowed towards the weir. As the hydraulic head increased, pluming was noted in the watercourse outside the perimeter berm in the area near the weir. To relieve the pressure, the weir elevation was lowered and the material allowed to flow freely into cell #2.

The area of leakage in the perimeter berm was sealed by laying a 6 mil film of polyethylene along the inner slope of the berm down to natural bottom and covering the liner with a 0.6 m layer of fine grained dredge spoil taken from an accessible corner of the containment cell. The weir was then restored and the remainder of the rehandling operation was carried out without further seepage, but considerably more material flowed into cell #2 than was anticipated.

A sample area of cell #1 (175 x 100 m) was seeded prior to freeze-up after the spoil had settled with a grass seed mix designed for this application to ascertain whether this type of material would sustain growth. The following spring it was found that the seeding had been successful.

One aspect of the rehandling procedure worth noting is that concurrent scheduling of dumping and hydraulic dredging in the reservoir must be avoided. The original design contemplated dumping only in the reservoir until it is full. Then only rehandling should follow so that environmentally it remains a closed system.

Material deposited in the reservoir should be rehandled into a permanent containment cell before the reservoir is completely filled. Otherwise dredging of contaminated materials will have to be deferred.

The first rehandling was scheduled to dredge a portion of the reservoir while concurrently dumping in another section of the reservoir. Some problems did occur as the dredging and dumping operations were carried out by separate contractors who claimed that each operation was hindering the other.

A report on environmental monitoring carried out while these projects were in progress observed that the silt curtain was open during these operations and recommended that in future the curtain remain closed during hydraulic dredging operations.

<u>SECOND REHANDLING OPERATION</u>

The experience gained by dealing with leakage of the perimeter berm during the first rehandling project led to sealing of the perimeter berm in cell #2 prior to dredging as part of the second project. The methodology for sealing cell #2 was similar to cell #1 using clay material from cell #1. Leakage in cell #2 was anticipated due to the coarse nature of the granular material used in construction of the perimeter berm as discovered while sealing cell #1.

The second rehandling contract was awarded in 1982 to the same company to dredge 150,000 cubic metres at a total cost of $659,000 using the same 16" hydraulic dredging plant. Although this project posed no problems of berm leakage, other problems pertaining to filling the cell arose.

This project involved rehandling deposited dredge spoil from a previously dredged area in the reservoir and also widening the reservoir which entailed dredging some hard clay from the natural bottom.

The rehandled dredge spoil flowed freely in the containment cell but the hard clay formed balls at the discharge, causing obstruction and back eddy flows. Extending the discharge pipe solved the problem temporarily but it became impossible to put manpower at the discharge to move the pipe. The discharge had to be moved to a new location, which corrected the flow but left an area within the cell at a lower elevation and created a ponding situation.

The entire area of cell #1 was hydraulically seeded after dredging and, although this was not as successful as the first application, heavy rains in late fall was the probable cause.

THIRD REHANDLING OPERATION

This project was awarded to a different contractor in August 1985 and involved rehandling 336,000 cubic metres of material at a total cost of $933,000 using a 20-inch suction dredge.

Hydraulic dredging was required in one section of the reservoir while spoil from another harbour dredging project was being deposited into the other section of the reservoir by another dredging contractor.

When the hydraulic dredging was completed in the first section, dredging commenced in the other section of the reservoir while dumping was still in progress. When the remaining dumping area was filled, dumping operations were moved to the dredged portion of the reservoir and the dumping area was dredged. An additional cut was made to further widen the reservoir and increase the capacity.

A leakage problem was encountered at the berm intersections of cells #2 and #3. As the discharge was decanting through the weir into cell #3, sealing of the westerly perimeter berm in cell #3 was indicated. By researching soils information of this area, it was determined that the berms were constructed on land covered with a one metre layer of organic material, including wood chips from a pulp and paper mill located adjacent to the site, and that leakage was occurring by migration through this organic layer under the berm. The area of leakage was sealed by excavating along the inner side of the perimeter berm to a clay layer below the berm, installing a polyethylene liner and backfilling with clay material. While this was done, the weir between cells #3 and #4 was lowered to divert the flow and lower the head in the cell.

Other problems occurred due to ice and freezing conditions brought on by extending work to early December. Discharged material was freezing in the cell and flow patterns of the material were altered due to this condition. The discharge pipe required moving frequently to prevent backwash.

On completion of the project, containment cells #1 and #2 were filled to capacity with material visible above water level in cell #3.

SUMMARY

By the summer of 1984, material in cells #1 and #2 had settled sufficiently so that a cover layer could be applied over cell #1. Some available containment capacity remains in cell #2. A project scheduled for 1985 will cover cell #1 hydraulically with clean dredged material, and another rehandling project is scheduled to fill cell #3 and ready it for final cover. Dumping operations in the reservoir from a carryover dredging project will be completed prior to commencement of hydraulic dredging. A new silt curtain assembly will be installed in the entrance to the reservoir cell prior to dredging to ensure a minimum particulate loss while dredging is in progress.

OPERATIONAL AND FINANCIAL CONSIDERATIONS IN FILLING, MAINTAINING AND MANAGING CONFINED DISPOSAL FACILITIES

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Dredged material disposal facilities constructed under the authority of the Great Lakes Confined Disposal Facility (CDF) Program, as authorized by Public Law 91-611, are constructed to prevent contamination of the Great Lakes, or localized parts of the lakes, from contaminants contained within dredged material. These facilities, once constructed, require varying amounts of effort and expenditures to operate and maintain.

LONG-TERM ANALYSIS OF PROJECT SEDIMENT QUALITY

Continuous verification of the need for confining dredged material is essential to responsible management of a maintenance dredging program. This is especially true in the Great Lakes where distinct options for productive dredged material use are identified, e.g. beach nourishment or establishment of wildlife habitat. The Detroit District maintains a five-year schedule of bottom sediment sampling and testing for all harbors which are known or suspected to contain contaminated sediments. An attempt is also made to sample and test sediments from "clean" harbors at least every ten years as a precautionary check.

The responsibility for bottom sediment analyses at United States navigation projects in the Great Lakes rests with the U.S. Army Corps of Engineers.(1) Methodologies used for bottom sediment handling and analyses follow procedures established by the Corps of Engineers and the U.S. Environmental Protection Agency.(2) Costs of sediment sampling per navigation project vary from $5,000 to as much as $75,000 every five years.

OPERATIONAL MONITORING OF CDF EFFLUENT AND ADJACENT WATER QUALITY

One of the major responsibilities in operating a CDF is to assure that effluents therefrom do not degrade the environment. Accordingly, water quality monitoring is routinely conducted at both the weir and outside perimeter of confined disposal facilities within the Detroit District. Monitoring parameters are based on contaminants identified during basic bottom sediment testing or those contaminants known or suspected to be present as a result of industrial discharges in the watershed. Costs of monitoring at a CDF during dredging operations range from $2,100 to $15,500 per year per project. An average cost for all harbors monitored in the Detroit District in 1984 was approximately $5,900.

EXTRA HANDLING COSTS ASSOCIATED WITH USE OF CONFINED DISPOSAL FACILITIES

The traditional dredged material disposal practice prior to 1970 in the Great Lakes was to dump most material into designated open water disposal sites.

As a result of the environmental concerns raised in the late 1960s, and the subsequent construction of confined disposal facilities, significant additional costs were incurred in disposing of dredged material into these constructed facilities.

The most significant increased cost to handle dredged material is the additional dredge travel and offloading time required to dispose into a CDF. For example, the cost of material transported from the Rouge River project near Detroit to the Pointe Mouille disposal site (46 miles round trip) in 1984, represented an increase of almost 50% per cubic yard over the cost to transport the material to the Grassy Island disposal site (12 miles round trip) in 1983.

In a similar example, the average cost over the last three years, for dredging and disposal of material from the East Outer and Lower Livingstone Channels of the Detroit River, with subsequent disposal into the Pointe Mouille CDF, has increased over 100% above the cost to dispose at an open water site.

Other extra handling costs associated with use of CDFs include use of booster pumps, front end loaders, dozers and trucks to distribute material within the CDF. Use of this type of equipment can add from one to two dollars per cubic yard each time the material is handled.

MAINTENANCE OF STRUCTURAL INTEGRITY OF CONTAINMENT DIKES

Maintenance of the CDF perimeter dikes can be broken down into two categories, i.e. annual routine maintenance and the repair of major damage resulting from a specific storm occurrence. Annual routine maintenance costs may average as much as $50,000 per year for a large disposal facility such as Pointe Mouille. An example of major damage were results from a severe north-easterly storm which occurred in Saginaw Bay, Michigan, in the spring of 1979. Repairs amounted to approximately $1,000,000 or about 7% of initial construction costs.

MISCELLANEOUS FACILITY MANAGEMENT ACTIVITIES

Responsible management of confined disposal facilities require a significant commitment of manpower and/or financial resources. On site inspections must be conducted routinely and after storms to ascertain the integrity of the dikes to perform their intended purpose. Topographical and/or hydrographic surveys must be performed as needed.

Some disposal facilities have experienced a problem with outbreaks of waterfowl botulism. To control the problem at the Saginaw Bay CDF, we established a botulism control management plan. The plan is manpower intensive but considered necessary if the proper circumstances warrant implementation.

MANAGEMENT OF PERMITTEE DISPOSAL ACTIVITIES

Public Law 91-611 provided for use of disposal facilities by permittees "upon payment of an appropriate charge for such use." Permittee fees range from \$1.40/cubic yard to \$20.60/cubic yard. Fee collection over the past five years has amounted to \$672,000.

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OPERATIONS AND MANAGEMENT OF THE DISPOSAL FACILITY - TORONTO HARBOUR

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Sediment brought down to Toronto Harbour by the Don River is the main cause for dredging in the harbour. The Don, with a drainage basin of 475 km^2 (180 sq. mi.) carried down annually about 30,000 m^3 in the preconstruction years (1940-1959), 120,000 m^3 during 1960-1969 construction (Don Valley Parkway) years, and 50,000 m^3 during post-construction years 1970-1984.

Dredgeate disposal in pre-1972 was in the open lake beyond the 58' (17 m) depth contour. 1972-1974 dredgeate was buried under sands dredged from Outer Harbour development. As a test in 1975, dredgeate was placed in a polder inside Hardpoint #5 of the East Headland, then the entrance sealed off. In 1976-1979 emergency dredging only was performed for navigation at cost up to 25 times higher than before due to rehandling by trucks into the polder of Hardpoint #5. Since 1980, the dredgeate has been placed in an endikement.

The usual Toronto Harbour Commission dredging rig consists of a combination floating heavy lift crane supplied with a clamshell - 3.5 cu. yd. (2.7 m^3) bucket, two 250 cu. yd. (191 m^3) bottom dump scows, and one to two tugs.

The present disposal facility, the Endikement, was designed and constructed not only to enclose dredgeate but to realign the Outer Harbour East Headland for more effective, less expensive armouring against waves. The core of the endikement dikes consists of non-leaking fines; the exposed edges are to be hardpoint-anchored pebble beaches heavily supplied with rubble. Situated in 10 m to 16 m (33 ft. to 52 ft.) of water, the Endikement forms three cells of 280,000, 530,000 and 2,200,000 m^3 volumes, respectively. The entrances to the cells are constructed with sills and narrowed to reduce dredgeate migration out to the lake, yet allow transit of the tugs and scow. The next-to-receiving cell acts as a wave stilling basin; the lake-most cell will have a vestibule to account for this. The dikes are designed to be high enough to preclude wave overtopping.

Dredging is performed in weather that will permit wash-out safe transportation (waves smaller than 0.55 m or 1.8 ft.), and also during non-icing temperatures. Disposal of the dredgeate is by beaching the scow in the cell furthest from its entrance. Dumping position is recorded in a log by the tug captain who also avoids resuspending material with tug's propeller. When the toe of the dumped dredgeate slope reaches the entrance sill, the entrance will be closed by end-dumping trucked material over it.

Monitoring of the placed dredgeate consists of soundings to determine top elevation and slope steepness. Repetition annually or semiannually yields information on consolidation. Use of a penetration cone sheds light on compactness. Water turbidity and chemistry during and after disposal is monitored by others.

For future needs, ideas are gathered regarding drainage of the dredgeate as well as overtopping for land, e.g. parks - use of aquatic, and marinas - use.

RESEARCH STUDIES FOR PREDICTION AND CONTROL OF LEACHATES FROM CONFINED DISPOSAL FACILITIES

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BACKGROUND

Analyses performed on sediments from within two specific reaches in Indiana Harbor indicate that the sediments are contaminated with polychlorinated biphenyls (PCBs) and various heavy metals. Because of the contaminated nature of the sediments, special precautions need to be employed during dredging and disposal of the sediments. Since site specific environmental constraints usually reduce the number of disposal options available for contaminated dredged material, the development of innovative disposal techniques is needed.

On a national basis, the Corps of Engineers must often dredge and dispose of highly contaminated sediments from federal projects. The Corps is committed to accomplishing this task in an environmentally responsible manner. Therefore, the situation found in the Indiana Harbor is not unique. Through extensive research and experience, the Corps has developed the expertise and procedures to dispose of contaminated sediments using available disposal and management practices.

Ongoing research and demonstration studies on Indiana Harbor sediments are being sponsored by the Chicago District, Corps of Engineers. This work is being performed at the U.S. Army Engineer Waterways Experiment Station (WES) in Vicksburg, Mississippi. The objectives of the studies are to develop and demonstrate innovative and environmentally sound equipment and procedures for dredging, transporting and disposing of approximately 200,000 cubic yards of highly contaminated sediments. The purpose of this paper is to present an overview of the research studies that address prediction and control of leachate from confined disposal facilities (CDFs).

THE PROBLEM

When contaminated dredged material is placed in a confined disposal facility, the potential exists for adverse leachate impacts on groundwater and surface water quality. Subsurface drainage and seepage through dikes may reach adjacent surface and groundwaters, resulting in deterioration of surface water quality and contamination of groundwater aquifers.

Therefore, the objectives of the research studies discussed in this paper are two-fold: 1) to develop technical input for planning level assessments of leachate generation rates and leachate quality in confined disposal facilities;

and 2) to develop innovative leachate control strategies for facilities predicted to have unacceptable water quality impacts.

RESEARCH APPROACH

Leachate Prediction

No routinely applied laboratory testing protocol exists that is capable of predicting leachate quality from confined disposal facilities. However, a predictive protocol for leachate quality is the object of the current research studies on Indiana Harbor sediments. The protocol in its current state of development involves both experimental leaching tests and procedures for extrapolating the laboratory leach data to the field situation using mathematical modeling.

Aerobic and anaerobic sequential batch leaching tests are being conducted on the sediment. Sequential batch leaching tests are batch tests where the sediment is challenged by fresh leaching solution over time instead of being continually exposed to the same solution. These tests will allow identification of the critical factors influencing contaminant mobility and quantification of release rates under varying environmental conditions that may be encountered in a confined disposal facility. The batch leaching tests will provide the desorption coefficients needed to model mass transfer of contaminants from the solid (particulate) phase to the aqueous phase.

Anaerobic and aerobic divided-flow permeameter leaching tests are also used to simulate field leaching processes. Permeameter testing is used to verify the mass transfer equation and the generality of the desorption coefficients determined in the batch leaching tests.

A one-dimensional, convective-dispersive mass transfer equation with a source term for contaminant leaching will be used to model leachate quality in the CDF and to estimate contaminant flux at the dredged material/site bottom interface.

Leachate Control

An innovative approach to leachate control is the laboratory investigation of the feasibility of physically and chemically stabilizing Indiana Harbor sediment by adding a setting agent(s). Specific tasks include: 1) screening of various candidate stabilization processes for their potential applicability to Indiana Harbor sediments; 2) physical properties testing of stabilized samples for strength and stability; and 3) chemical leachability tests on stabilized sediment samples meeting minimum physical properties criteria. Some of the setting agents being investigated include cement, flyash, blast furnace slag, silicates and various combinations. In addition to the setting agents, the laboratory studies will include an evaluation of the potential for incorporating a sorbent material to assist in the stabilization/solidification processing.

STATUS OF STUDIES

The leachate predicting study was initiated in January 1985. Initial batch testing of anaerobic sediments to determine contaminant release rates has been completed. A shaking time of one day is sufficient to obtain a "steady state" relationship between dissolved and sediment-bound contaminants in the batch tests. The effect of sediment to water ratios on contaminant releases has been evaluated. A 4:1 ratio was selected as optimum for further studies.

Divided-flow permeameter testing of the Indiana Harbor dredged material has verified the loading characteristics and velocity of permeant through the dredged material. A noncontaminating teflon material has been developed for use as a seal and filter in the permeameter. Permeameter testing is continuing to collect data for field extrapolation and verification of the batch extraction tests.

Samples of the sediments have been furnished to two participating commercial vendors for evaluations of their stabilization processes. Because this study was only recently initiated (March, 1985), no research results are available at the time of this writing.

LONG-TERM MONITORING OF TIMES BEACH AND OTHER CONTAMINATED CONFINED DISPOSAL SITES

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BACKGROUND

Several Corps of Engineers (CE) Districts have identified the need to evaluate the movement of contaminants from dredged material into plants, animals, and hydrological components at confined disposal sites. Such a site is at Times Beach in the Buffalo District. The District has been requested to release the Times Beach confined disposal site for recreational use by the Municipality of Buffalo, New York. This site was filled to one-half its capacity with highly contaminated dredged material and not filled further as a prolific wildlife population developed and the Municipality of Buffalo requested that the site be kept with its combination of upland, wetland and aquatic habitats for wildlife. Prior to releasing the site to the Municipality, the Buffalo District initiated contaminant mobility studies through the Waterways Experiment Station (WES) and through joint Netherlands Organization for Applied Scientific Research (WES-TNO). Contaminant mobility studies conducted to date at Times Beach have been positive in delineating potential routes of bioaccumulation within the ecosystem (Marquenie and Simmers, 1984). Work sponsored by the Buffalo District, the WES, and the Netherlands Government has addressed the mobility of toxic heavy metals and organic contaminants in the aquatic, wetland and upland portions of Times Beach. The data collected has been the first of its kind and has been critical as a first step in the development of appropriate long-term management strategies applicable to confined disposal sites containing contaminated dredged material both in the United States and the Netherlands. The funding available for the current year will allow an extensive study of Times Beach and limited comparison with other sites containing similarly contaminated dredged material, such as the Dutch Broekpolder. Additional funding will be required to fully exploit monitoring possibilities and evaluate management procedures that may be necessary for future recreational uses of such sites. Other confined disposal sites need to be examined in light of the Times Beach knowledge in order to evaluate status of contaminant mobility.

OBJECTIVES

Objectives of this study fall in two groups: 1) the work planned and funded for the current year; and 2) a potential long-term monitoring study of confined disposal sites through 1991. This second portion of the program is unfunded at this time.

1) Objectives for the current year:

(a) Collect and interpret all existing background data concerning Times Beach. This will include physical data such as groundwater surveys, levels of Lake Erie, weather records and other information as is available, and biological data from the local ornithologists, naturalists, institutes and museums.

(b) Survey the site carefully and draw a map to facilitate the delineation of the plant and animal communities in relation to the arrangement of the contaminated materials.

(c) Make sufficient soil borings to allow the construction of a three-dimensional map of the strata of varying contaminant levels or contaminant availability.

(d) Sample existing components of the upland, wetland and aquatic ecosystems to determine food-web contaminant transfer in each ecosystem. Comparisons of plant and animal contaminant levels will be compared to those of other disposal sites where the same species are present. It would be appropriate to compare the wooded upland portion of Times Beach with areas of the Broekpolder having the same tree and earthworm species.

(e) Locate a suitable regional reference area for plant and animal tissue contaminant level comparisons as well as evaluation of differences in species diversity and associations.

2) Objectives for a future program:

(a) Survey CE Districts for other disposal sites that have evolved into extensive wildlife areas and select additional field sites.

(b) Expand the comparison with the Broekpolder by selecting regions that approximate other United States disposal sites.

(c) Examine long-term sublethal effects of contaminated dredged material on the plant and animal inhabitants. This should include investigations of mutagenicity and chronic effects.

(d) Extend contaminant mobility monitoring to salt water disposal sites.

(e) Utilize data collected to further develop the use of analysis for "indicator" contaminants and refine predictive techniques.

ORGANIZATION OF WORK

This work will be managed through the WES with points of contact for each task designated within the Contaminant Mobility and Regulatory Criteria Research Group. While the prime responsibility for the research program will rest with the WES and TNO, maximum use will be made of the local personnel of the Buffalo District, Buffalo-area institutes, universities and other federal agencies that have been involved in portions of the work at the site and on similar topics in the area. The WES principal investigator met with the potentially valuable resource persons and organizations and will coordinate their efforts. These resources should be capable of accomplishing both routine monitoring and on-site activities. All bioassay and biomonitoring efforts will be planned jointly by the WES and TNO with reference to the planning input of the Contaminant Mobility Working Group meeting on-site May 13-17, 1985. This group will make suggestions based on the existing background data and WES-TNO work to date to fine-tune the biological program. Representatives of the WES and TNO will carry out or monitor all ecotoxicological testing and biomonitoring experiments. The facilities of the WES will be used for bioassay tests planned jointly by the WES and TNO. The Broekpolder comparison data collection will utilize TNO facilities in the Netherlands, and again, appropriate local institutes will be employed where applicable.

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CONTAMINANT MOBILITY STUDIES FOR TIMES BEACH CONFINED DISPOSAL FACILITY BUFFALO, NEW YORK

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The Times Beach disposal area is a 45-acre confined dredge disposal area near the confluence of Lake Erie and the Buffalo River. The site received approximately 550,000 yd^3 of polluted dredge material from the Buffalo River and Buffalo Harbor from the period 1972 to 1976. While being filled, the area became intensively used by migratory waterfowl, songbirds and other wildlife. At the request of local environmental groups, filling was stopped in 1976 because of the large numbers and varieties of birds using the site. The completely enclosed area now contains about 50% shallow open water (1-7 feet), 25% marsh and 25% scrub trees, mainly cottonwood.

Although the area is observed to foster lush vegetative growth and abundant wildlife there is concern that contaminants from the sediment may accumulate and bioconcentrate in plant and animal food chains. Consequently a long-term program has been initiated to study bioaccumulation by aquatic and terrestrial plants and animals and possible effects on organisms including growth, reproduction, vitality and carcinogenicity. This paper describes initial work on chemical characterization of sediment and bioaccumulation by plants, earthworms and fish. Principal contaminants found in the sediments include the heavy metals: zinc, cadmium, copper, arsenic, mercury, chromium and lead, and organics including chlorobenzenes, polynuclear aromatic hydrocarbons (PAHs) and aniline compounds.

The sedge, Cyperus esculentus, was planted at various locations in the dredge sediment, harvested after 45 days and analyzed for heavy metals and organics. Uptake of organic pollutants was insignificant. The heavy metals cadmium, chromium, iron and possibly arsenic were in higher concentrations than normally found in wetland plant communities of the Great Lakes. Earthworms incubated in Times Beach sediment for 28 days were found to have increased levels of cadmium, arsenic, mercury, PCBs and PAHs. Native worms from the disposal area were also found to accumulate heavy metals, PCBs and PAHs.

Fish samples collected from the open water at the Times Beach site did not accumulate elevated levels of heavy metals, but did have elevated levels of PCBs and PAHs. Mercury and PCB levels in fish did not exceed "tolerance or action" levels for edible fish, i.e. muscle. Accumulation of organics by fish livers was somewhat higher than by muscle.

Future work to be described in an accompanying paper will address studies to be conducted on organisms higher in the food chains (birds, mammals) and effects on animal vitality, health, reproduction and community structure.

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CHICAGO AREA CDF SYNTHETIC LINER AND SAND BLANKET EXPERIENCE

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The Chicago area Confined Disposal Facility (CDF) was constructed by the U.S. Army Corps of Engineers (USACE), Chicago District in 1982-84 to receive maintenance dredgings from the Calumet River and Harbor and Chicago River and Harbor. The CDF is located in Calumet Harbor, Chicago, Illinois. It is a triangular facility of 43 acres, extending out from the existing shoreline. The CDF is constructed of a rubblemound dike, with a core of prepared limestone, and a crest elevation of +12 feet LWD. The dike was constructed with a synthetic membrane liner along the entire interior face. A plastic, flexible liner (30 miles) with polyester fabric reinforcement was installed in 200 foot-long sections, heat welded in the field. The liner was placed against the prepared limestone, with additional stone placed on top. It is believed this was one of the first installations of a synthetic liner underwater.

During and after construction of the dike, observations suggested that the liner was not intact. The best evidence of this was the record of water levels within the CDF relative to lake levels fluctuations. The water level of the CDF directly followed the lake with no appreciable lag. A dye study of a portion of the CDF indicated that the liner was perforated randomly, rather than in a few specific areas. Measures to correct the situation were examined, including grouting and slurry walls.

The Chicago District decided to construct a blanket of silty-sand along the interior face of the CDF dike. It was hoped this material would act in two ways. The silty-sand blanket could be a barrier of low permeability, and sand could move through perforations in the liner and promote clogging of the prepared limestone. The silty-sand was excavated from the lake bottom within the CDF and placed mechanically against the dike on a 3:1 slope. Water level records within the CDF following placement of the "sand blanket" indicate that it has greatly retarded the interchange between the harbor and CDF. The CDF is no longer responsive to short-term lake level fluctuations, but does follow long-term fluctuations with a lag.

The Chicago District plans to manage the operation of the CDF in a manner which will further reduce the exchange of water between the harbor and the CDF. The next two maintenance dredging operations will include placement of dredged materials along the sand blanket to help its stabilization. The use of local lake sand at this CDF has been so successful that it is being incorporated into a future CDF design as an integral portion of the dike.

CHICAGO AREA CONFINED DISPOSAL FACILITY FILTER CELL PERFORMANCE

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The Chicago area Confined Disposal Facility (CDF) was constructed in 1982-84 by the U.S. Corps of Engineers, Chicago District. The facility was required by the State of Illinois to meet very strict standards on the quality of the return water or effluent. These requirements include the pumpage of water from the CDF during dredged material disposal to eliminate a positive hydraulic head with the adjacent harbor/lake. Water pumped from the CDF is passed through filter cells with granular filter media. The filtered effluent is required to contain 15 mg/L suspended solids or less.

The Chicago Area CDF filter cells were designed using criteria established in a study conducted during the Dredged Material Research Program (ref. 1). The cells are made of concrete, 34 feet in diameter (ID) and 24 feet deep. They were designed for rapid gravity filtration, two gallons per minute per square foot, with an operating head of up to nine feet. The cells contain graular media of crushed anthracite (2.0 m) over coarse sand (1.7 m) with a gravel underdrain and a woven geotextile separating the sand from the underdrain. The cells were designed to be operated in association with hydraulic dredging operation. The design called for one cell to operate for a single dredging season, after which the filter media will have clogged and be replaced. They have been operated twice, once during construction, and during the first maintenance dredging operation.

During the first operation, one cell was loaded at near the design flow and solids concentration for less than ten days. The filtration performance was almost exactly at the design solids removal (85%). However, the cell became clogged after only 5-6 days. The design criteria for filtration systems (ref. 1) included a solids capture of 0.3 grams solids per cm^3 filter media before clogging. Borings of the filter media in the clogged cell were made, and samples analyzed to determine the amount of solids captured. The fines were washed off the sand and anthracite samples, collected, and weighed. The solids capture was fairly uniform at 0.04 g/cm^3 except for the bottom one foot of media. Although sample recovery was poor for the bottom one foot, it was determined that the solids capture for this sample was 0.34 g/cm^3. Reevaluation of the filter cell design was focused on the woven geotextile used to separate the coarse sand from the gravel underdrain. The fabric is suspected of causing excessive solids capture in the lower level of the sand and also the fabric itself blinding.

The other filter cell has been operated at a reduced flow during disposal of mechanically dredged materials in October-December 1984. The hydraulic and solids loadings were approximately 43% and 20% of the design influent capacities. Filtration efficiency was just less than 60% during this operation.

The operation of the filter without tailwater, and the resulting excessive surface loadings to portions of the filter are believed responsible for the reduced filtration efficiency. A valved discharge line is being considered to create an artificial tailwater condition and more uniformly distribute flow.

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STATUS AND TRENDS OF CONTAMINANTS IN HARBOUR AND CHANNEL SEDIMENTS IN THE CANADIAN GREAT LAKES

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Bottom sediments are a primary sink for contaminants in the Great Lakes. Upon entering the lakes, many contaminants become associated with the fine-grained sediment or particulate organic matter and are transported into the depositional basins. Consequently, the concentration of sediment-associated contaminants in depositional basins reflects the loadings to each basin. However, contaminants often accumulate in the nearshore zone where the shoreline morphometry or constructions, such as a breakwater around a harbour, restrict further transport of fine-grained sediment into the open lake. These areas become sinks of fine-grained sediment and the concentration of the sediment-associated contaminants usually represent loadings from local sources. In harbours located at a tributary mouth, contaminants in the sediment represent the loadings from the river-stream drainage basin.

Of the over one hundred harbours on the Canadian side of the Great Lakes, many are subject to either routine or periodic dredging. Prior to any dredging event, clearance for disposal is required from federal and provincial environmental protection agencies. The concentration of contaminants in a harbour sediment provides information on sources of contamination and input for the primary environmental assessment and review process (EARP) for dredged sediment disposal.

During 1978-81 sediment was collected from 78 harbours on the Canadian side of the Great Lakes (Mudroch and Sandilands, 1979; Thomas and Mudroch, 1979). The concentration of contaminants in the collected sediment was assessed in light of present disposal guidelines and evaluated against ambient concentrations reported in the Great Lakes sediment.

The assessment of harbour sediments was carried out in a set pattern, as follows: 1) comparison of mean values for parameters against the present guidelines for dredged material disposal; and 2) parameters exceeding the recommended guidelines were compared against the ambient concentration reported for the open lake sediments. Where sufficient data on past dredging were available, a comparison of dredging load against mean annual loading to the adjoining lake and lake sedimentary basin was carried out. Finally, a comparison was made with the quality of the suspended sediment of the inflowing river, for those harbours subject to such an inflow.

Recent investigations of contaminants in Lake Ontario sediments revealed significant concentration of many toxic organic compounds (Allan et al. 1983).

However, only PCB are included in the present Ontario dredging guidelines. Limited information is available on organic contaminants in the sediment of Canadian Great Lakes harbours.

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STATUS AND TRENDS OF HARBOR SEDIMENT CONTAMINATION IN THE UNITED STATES LOWER GREAT LAKES

John R. Adams
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Awareness of the role of sediment contamination by metals and organic chemicals grew slowly during the late 1950s and the 1960s. By 1970, the public was fully aware of the gross contamination of sediments of the Great Lakes and demanded that cleanup begin. In 1971, PL 91-611 mandated the construction of confined disposal facilities (CDFs) to contain the most heavily polluted materials and prevent their introduction into the open lake ecosystem. PL 92-500 in 1972 mandated the national effort to clean up our waters and provided that within ten years the sediment should be clean enough to resume open lake disposal.

Since the passage of these laws, many CDFs have been built and water quality has improved. Construction of new CDFs is still planned to contain heavily contaminated sediment for another ten years. There have been some successes. In Toledo, Ohio as of 1985, the Corps has received a Water Quality Certification for the open lake disposal of half of the sediments dredged from the Maumee River. We are also applying to the State of Ohio for similar certification for disposal of sediments from the Rocky River. In general, however, the harbors remain heavily contaminated and may actually have worsened in recent years.

In 1982, the Buffalo District completed the Lake Erie Wastewater Management Study. One output of the study was an analysis of chemical loadings to Lake Erie for the period 1970-1980. The studies showed in particular that total phosphorus loadings to the lake had decreased over the period. The study also demonstrated that in-lake total phosphorus concentrations had decreased.

Another aspect of the Lake Erie Study was an analysis of land management practices, which have a potential for decreasing diffuse source sediment and phosphorus loadings by an amount sufficient to achieve the loading objectives of the Great Lakes Water Quality Agreement.

PROBLEMS AND TRENDS OF HARBOR SEDIMENT CONTAMINATION
IN THE UNITED STATES LOWER GREAT LAKES

John R. Adams
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DREDGING AND CONFINED DISPOSAL FACILITY OPERATIONAL MONITORING FOR UNITED STATES HARBORS IN THE UPPER GREAT LAKES

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Responsible project management at United States navigation projects in the Great Lakes requires the evaluation and reporting of the effects of our activities on water quality. This evaluation and reporting is especially important at navigation projects which include confined disposal facilities (CDFs) to retain contaminated dredged material. Effective management of disposal sites has a direct impact on maintenance dredging activities required to ensure the uninterrupted flow of commercial and recreational traffic within the Great Lakes.

FORMING AND IMPLEMENTING THE MONITORING PLAN

The plan for monitoring each CDF consists of determining monitoring station locations, establishing frequency of monitoring, and determining testing parameters or individual tests to be performed on each sample. Once the plan is developed and a scope of work is written, a contract to perform the sampling and analysis is awarded to a prequalified commercial laboratory. Sampling starts immediately before disposal into a CDF takes place and a discharge from the facility begins and is continued, periodically, until disposal is completed.

SPECIFIC CONSIDERATIONS IN CDF MONITORING

Generally, about 20 parameters are monitored to sufficiently measure the impacts of discharge from a disposal facility. Decisions as to which parameters to test for are based on channel sediment testing data and past monitoring results. The frequency of monitoring is based mainly on the remaining capacity of the facility and pumping rate of the dredge since these factors are most directly related to retention time and quality of effluent. Duration of disposal and known problem contaminants, which must be given specific attention, are also used to determine frequency of testing. Overflow monitoring is usually performed every ten days to two weeks while outflow is occurring from a CDF. In Wisconsin, monitoring is completed approximately every three days at the request of the Wisconsin Department of Natural Resources.

The confined disposal facility monitoring program in the Detroit District typically consists of taking five to nine samples on three or four occasions at approximately six disposal facilities per year. Typically, samples are taken at the weir overflow, the lake or river adjacent to the facility, ambient locations to check background levels, and other stations as necessary including the dredge discharge to characterize what is going into the CDF. The data are compared to ambient conditions and EPA water quality guidelines.

Operations are halted if ambient levels are being elevated significantly. If weir overflow concentrations are high, and/or plume concentrations are high, but ambient levels are not being affected, disposal normally is continued while operational corrections are made. Groundwater is also sampled at several disposal facilities. Well points have been installed outside the facility for that purpose.

USE OF MONITORING DATA

Data obtained from confined disposal facility water quality monitoring is analyzed to provide both short-term control of ongoing dredging operations and background data for long-term modifications to existing facilities or planning for design modifications to proposed facilities.

WILDLIFE UTILIZATION AND MANAGEMENT OF THE CONFINED DISPOSAL FACILITIES IN THE GREAT LAKES

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BACKGROUND

Confined disposal facilities (CDFs) are increasingly common structures being built on waterways of the United States by the Corps of Engineers (CE) to hold dredged material. In the five Great Lakes, almost all dredged material is placed inside containment structures whether or not the material is contaminated. At the present time, 41 CDFs are in use or planned by the three Great Lakes CE Districts - Detroit, Buffalo, and Chicago. These CDFs were constructed with disposal capacities and long-term use as the primary considerations. However, most of them also receive considerable use by fish and wildlife, and several of the newer CDFs were designed with benefits to wildlife and fisheries resources as one of the objectives. Most of the CDFs in the Great Lakes are onshore sites, but several are CDF islands, most notably at Pointe Mouillee, Toledo, the channel islands below the St. Marys River, and the Detroit River islands.

GENERAL WILDLIFE USE

Wildlife use of CDFs differs by type of CDF, its location, sources of disturbance, type and texture of dredged material, frequency of disposal, and projected land use. For example, island CDFs generally are used more by waterbirds than are onshore CDFs. A variety of small mammals are more frequently found in onshore CDFs even though bird species still dominate. In general, all CDFs in the Great Lakes and elsewhere in the United States are used primarily by bird species. Relatively few mammals can live year-round on such sites due to the general lack of suitable habitat for mammals. Birds can move about their territories much more freely, and are usually migratory. Thus, they can move in response to habitat changes, such as new disposal operations, without undue stress.

Mammal species which are generally highly adaptable and which will live in a broad range of habitats are the species most commonly found on dredged material sites. In the Great Lakes, red fox, raccoons, mink, skunks, muskrats, white-tailed deer, beaver, cottontails and small rodents have been found inside CDFs.

Over 145 species of birds have been found in Great Lakes CDFs; numerous other species occur at other CDFs in the United States, especially on the Gulf Coast. These bird species generally are of waterbirds, waterfowl, raptors, and songbirds. Raptor and songbird species are usually those which frequent more wet, open or shrubby habitats rather than wooded areas. Considerable use of CDFs is made during migration by all of these bird groups and a number of these species were only observed at CDFs during migration. Large flocks of songbirds especially have been noted on the migratory route along Lake Michigan and Lake Erie shorelines.

A CASE STUDY: POINTE MOUILLE

An excellent example of one of the newer CDFs in the Great Lakes is Pointe Mouille Diked Disposal Island in western Lake Erie. Pointe Mouille dikes have been under development by Detroit District for over 11 years. All engineering operations on the island portion and the dikes were completed in 1983. The marsh phase of site development, including construction of the marshes, marine, visitors' center, public walks and areas and fishing facilities, is underway. The existing marsh inside the installed culverts behind the containment facility is developing naturally, nourished by sediments trapped by channeling part of the Rouge and Huron Rivers through the marsh. The nesting island built of dredged material is covered with tall vegetation and the fringes are being used by nesting waterfowl. Portions of the shoreline have been planted in grain fields for wildlife by the Michigan Department of Natural Resources, since the structure is part of the Pointe Mouille State Wildlife Management Area. Much of the barrier island dike compartments has been filled to capacity with dredged material, and they are colonizing naturally with locally occurring plant species. The inside of the containment area still has ponded areas with marsh fringes that receive considerable use by seabirds and long-legged waders. Black-crowned night herons, great egrets and great blue herons are especially common.

The island is scheduled to be planted with perennial grasses and forbs when it is completed to create nesting and grazing meadows. Capping the dredged material with two feet of clean soil is also being considered. The dikes of the island have had waterbird use for loafing and feeding since construction began, primarily by gull species. This follows the expected pattern for construction in Lake Erie noted in the 1970s in which virtually every new site built for disposal operations was colonized by nesting seabirds if the site provided suitable habitat at all.

A management plan for the site was drafted in 1980-81 and is being followed by both Detroit District and the Michigan Department of Natural Resources. The site is the only one in the United States in which a CE District has applied and received permission to use Section 150 funds for wetlands development, and up to $400,000 has been earmarked for habitat development of Pointe Mouille.

The Pointe Mouille site receives heavy use by fishermen throughout the year and by hunters in season. It is less frequently used for boating, hiking and bird-watching although it is well-suited for all three. The Detroit District has fenced and gated the entire site and the Michigan Department of Natural Resources protects and controls access to the site.

SUMMARY

Research on dredged material disposal sites, including the Great Lakes, has provided a strong source of technical information from which to base long-term beneficial uses plans for CDFs. Techniques are known, and case studies such as Pointe Mouille have been made where management for wildlife was considered feasible and desirable as a part of the overall disposal operations and site development.

SUMMARY

Research on dredged material disposal sites, including the Great Lakes, has provided a strong source of technical information from which to base long-term beneficial uses plans for CDFs. Many of the case studies such as Pointe Mouillee have been made where management for wildlife was considered feasible and desirable as a part of the overall disposal operations and site development.

A CASE STUDY OF HAMILTON HARBOUR CONFINED DISPOSAL FACILITY

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INTRODUCTION

The Port of Hamilton is located in a natural harbour setting at the most westerly end of Lake Ontario. Throughout its history, the port has grown steadily to become one of the leading ports in Canada. It provides a variety of services to meet needs of domestic and foreign markets. The two largest steel producers in Canada, Stelco and Dofasco, are located in the port along with numerous support industries.

Responsibility for the operation of the harbour activities remained with the City of Hamilton officials until 1912 when the Hamilton Harbour Commissioners (HHC) was incorporated through an act of parliament. The act made HHC responsible for the administration and supervision of all activities in this harbour and the development of waterfront properties for shipping, navigation and related purposes. Throughout the years, HHC has attempted to provide a blend of services to industry, commerce, and the community by recognizing the various needs and adopting a master plan for the harbour development which encourages multi-faceted use.

Public Works Canada has participated in the port growth by providing engineering servies to HHC for the design and construction of their harbour structures and dredging activity.

HARBOUR DEVELOPMENT

Since 1912, the harbour has developed from west to east. As wharves were constructed, channels and berths were dredged to meet the navigational depth requirements. Most of the existing wharves were constructed with a perimeter stone or slag berm in which the interior was filled with material dredged from adjacent channels and berths. Facewalls constructed with steel sheet piling were added to permit adjacent vessel berthing. The majority of the construction occurred in the 1950s (West Harbour) and 1960s (East Harbour), with some wharves reconstructed in the 1970s. Stelco and Dofasco properties had also undergone major expansion and land reclamation in the '50s and '60s.

Throughout this period, any material dredged from navigational areas which was not used to reclaim land was usually dumped into deep waters of the bay.

By 1957, plans to develop the Strathearne Avenue wharves (Pier 23 and 24) were put into motion. Dredging an approach channel, turning basin and slip was needed to service this area by water. A portion of this dredged material was placed in the present Pier 25 location thus initiating the development of the confined disposal facility.

DISPOSAL FACILITY

The exterior berm of the total disposal facility (Pier 25, 26 and 27) was constructed in three stages. In 1958, the first slag berm for Pier 25 was constructed to enclose material originally dredged from the East Harbour Approach Channel. Measuring 913 m long, the channel and a 244 m radius turning basin was dredged to 6.4 m depth below datum. Further maintenance dredging, widening and deepening of channel areas necessitated a second berm to be built in 1966 to create an additional cell. In 1972, as a result of a land transfer to HHC, the existing channel had to be extended to 1,890 m in length and realigned to permit lakeward expansion of the Stelco and Dofasco properties. To accommodate the proposed 918,000 m^3 of dredged material and future requirements, the third berm was constructed to form part of Pier 26 and 27. A 4.88 m wide, 1,577 m long berm was built with 76,841 m^3 of slag and 82,040 m^3 of 50-200 mm and 200-300 mm stone. Simple truck end-dumping techniques were used to construct the berms.

With the berms completed, a 50 hectare confined disposal facility with an approximate total capacity for 3.0 million m^3 was created. The facility would be filled with both dredged material and other fill materials. Designated for future industrial development, it would provide 1,860 m of ship berthing with marine and industrial sites. Total expenditures for the construction of all exterior and interior berms since 1958 has amounted to \$1.7 million, which is inexpensive for a disposal facility of this magnitude.

In the early 1970s, environmental concerns and increased sensitivity about open lake disposal of contaminated material in this harbour surfaced. Since 1972, virtually all material dredged from the harbour has been deposited into this site by either hydraulic or scow dumping operations. Only material dredged from the East Harbour has been hydraulically placed using hydraulic cutter suction dredges ranging in size of 300 mm to 500 mm diameter. The remaining material from the West Harbour area has been scowed to the site and bottom dumped within the confines of the perimeter berm.

To permit scow dumping, the north berm is temporarily cut open to allow fully loaded scows into the facility. We attempted to fill from the southerly area towards the north berm in order to make use of all available dumping space. In 1981, as available dumping space diminished, we were confronted with several issues: 1) remaining disposal capacity; 2) how to best manage this site for future scow and hydraulic placement operation; and 3) economics of constructing future disposal facilities. Remaining disposal capacity in Pier 27 is approximately 720,000 m^3 of dredge spoil, which is sufficient for the next 15 years of dredging activity depending upon progress of East Port development. However, better management of the site was needed to make this workable and economically feasible. A future disposal facility would be expensive and thus construction should be delayed until there is a need. With an immediate need to improve site management, construction of interior berms to create a cell structure was implemented.

Interior berms permit a staged development of the site, improve control of dredged slurry deposition and improve containment of pollutants by enhancing settlement of fine sediments. They were built with a mixture of construction fill and foundry sand supplied by nearby steel mills. Since fill material was scarce and to minimize construction costs, the size of berms was reduced to the minimum required for construction equipment. Simple overflow weirs were provided for each cell and located in order to enhance settling of fine grained sediments. At the weirs, the berms were lined with filter fabric and covered with rip rap to prevent berm erosion during hydraulic dredging operations.

Between the completion of interior berms and commencement of dredging operations, longitudinal cracks in the berms developed. The cause was not determined. Other factors like poor foundation soils, small berm size, potential range of water pressure and flow velocities due to various available dredging equipment were added to the question of berm stability which had to be resolved. To reduce the risk of berm failure during dredging operations, the overflow weirs were built in stages to minimize the effects of all factors. During dredging operations, the weirs were raised in intervals of 0.5 to 1.0 m to permit gradual filling of each cell. The result was a successful operation. As the present cells are filled, future cells will be constructed in a similar fashion.

In the past two years, a reservoir cell was created in cell #4 to be used as a scow dumping area. The 31,500 m^2 area was deepened to 4.9 m below chart datum and will hold approximately 100,000 m^3 of material before it would be hydraulically rehandled into the final cell.

ENVIRONMENTAL CONCERNS

The sediments in Hamilton Harbour are the most polluted of all commercial port facilities within the Canadian Great Lakes system. As shown in Table 1, mean concentrations for almost all recording contaminant parameters are orders of magnitude in excess of recommended guideline values for open lake disposal. Thus all material dredged from this harbour must be confined within a disposal facility.

Several techniques were used to obtain effective disposal of contaminated sediments. The multi-cell facility technique was tested during a recent single round of effluent quality tests conducted during a hydraulic project. As the dredged slurry was being pumped into the first cell of the facility, the supernatant travelled through three more cells before being allowed into open water. The results shown in Table 1 indicate excellent particulate retention, with the water quality in the last cell comparable to ambient water conditions in this area.

When the perimeter berm was opened for scow dumping, an experiment was attempted to minimize the escape of contaminants into the harbour by installing an air bubbler curtain consisting of an air compressor, plastic perforated pipe and weights. It was installed and maintained during one project at a cost of $10,000 and was effective in the short term, but proved inconclusive in the long term. Its effectiveness was disturbed by the effects of wave conditions, currents and scow movements. Future projects were carried out without the air curtain.

TABLE 1. MINISTRY OF THE ENVIRONMENT GUIDELINES AND HAMILTON HARBOUR SEDIMENT AND EFFLUENT WATER QUALITY DATA

Parameter	MOE Guidelines for Open Lake Disposal of Sediments	Levels in Sediments of Hamilton Harbour		Effluent Quality in Cell (mg/L)			
		Max.	Min.	2	3	4	Outside (Ambient)
LOI (%)	6.0	29.9	9.8				
PCBs mg/kg	0.05	3.1	.74	40	3	0.5	0.5
TP	1,000	5,950	640				
TKN	2,000	10,300	2,050				
COD (%)	5	34.6	5.8				
Oil and Grease mg/kg	1,500	15,000	1,080	360	10	5	4
As	8	13	6	5.4	0.003	0.001	0.002
Cd	1	5	1	0.331	0.0002	0.002	0.002
Cr	25	615	62	93.5	0.110	0.02	0.02
Cu	25	195	26	16.4	0.115	0.05	0.05
Pb	50	264	47	16.3	0.03	0.03	0.03
Hg	0.3	0.804	0.285	0.16	0.1	0.1	0.1
Ni	25	66	38	4.96	0.068	0.039	0.023
Zn	100	1,485	85	96.5	0.135	0.040	0.061
Suspended Solids				26,316	64	14	9
Total Solids				26,692	488	396	464

A curtain made of synthetic fabric installed across the opening was also tried. This proposal requires regular maintenance and presents difficulties if required to be opened for scow passage. The biggest difficulty with this system is obtaining ample coverage of the opening to prevent sediment transport through berm - fabric interfaces.

Most dredged material consisted of poor soils, organic muck, slurry, oil and grease, debris and the occasional sand and gravel, and is largely unsuitable for foundation purposes. Construction fill material was imported to ready the site for future development. The fill was used to surcharge the poor soils so that acceptable soil bearing pressure of 100 kN/m^2 could be achieved. To achieve this consolidation, the fill was piled to a size of 121 m wide by 243 m long by 4.6 to 5.5 m high. Piezometers were installed to monitor consolidation progress. After surcharging was completed, the fill was spread to provide a cover for the dredged material. Depending upon the degree of settlement, a minimum cover layer of 1 m thickness was placed over the material.

PRESENT STATUS AND FUTURE DEVELOPMENT

Approximately two-thirds of the total disposal facility has been filled to date. The remaining area available to receive dredged material is known as Pier 27 and a portion of Pier 26.

With increased demand for additional marine/industrial sites, the development of the East Port (Piers 25, 26 and 27) began in 1983 with the development of Pier 25 (Stage 1). Site services consisting of arterial roads, sewers and utilities were constructed in 1983 at a cost of $2.0 million. In the following year, road-rail bridge connecting the existing port to the East Port was constructed for $1.1 million. The third phase consisting of a 244 m long steel sheet pile facewall was completed in March 1985 for $1.7 million. The adjacent area to the north will be surcharged so that the next 366 m of facewall can be constructed. This will complete the development of the 18 hectare Stage 1 (Pier 25) site for which tenant leasing is currently being arranged by HHC.

An additional phase is currently scheduled for 1986 which will consist of providing site services for Pier 26. Further development of Stage II (Pier 26) will occur as economic conditions and market demands improve.

CONCLUSION

The disposal facility has been a key to the successful confinement of contaminated dredged material for Hamilton Harbour. Without it, navigational channels could not be maintained with the minimal disruptions to shipping as has been experienced. Its vast size has contributed to successful retention of contaminated sediments. The land reclaimed by this facility will serve a useful purpose of creating valuable marine and industrial sites for future growth requirements of the Port of Hamilton.

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A CASE STUDY OF SOUTH EAST BEND/ST. CLAIR RIVER CONFINED DISPOSAL FACILITY

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South East Bend Channel is located at the lower end of the St. Clair River where it empties into Lake St. Clair. All shipping between Lake Erie and Lake Huron passes through this channel.

In 1960, as an improvement to the new St. Lawrence Seaway System, South East Bend Cut-Off Channel was cut through the Walpole Island Indian Reserve in Canada in order to bypass the original South East Bend Channel, which had followed the International Boundary in a wide curve and was considered unsuitable for seaway shipping traffic.

The new channel was constructed under a bilateral Agreement between the United States and Canada. While the original South East Bend Channel was maintained by the U.S. Corps of Army Engineers along with adjoining sections of the main shipping channel (the Cut-Off Channel), approximately five miles in length was maintained in Canada.

During the late 1960s the first indication of a requirement for maintenance dredging of the Cut-Off Channel was accompanied by the discovery of mercury contamination within the St. Clair River area. Tenuous negotiations for the development of an environmentally acceptable disposal solution for the contaminated dredged material took place between 1970 and 1977, when approval was finally obtained for creation of three containment cells on an adjoining part of the Walpole Island Indian Reserve known as Seaway Island and for a first five-year phase of dredging, filling the cells and covering the dredged material with suitable vegetation. By this time the Cut-Off Channel had become quite restricted.

The cost of the five-year project completed in March 1982, was \$8.5 million with a storage capacity of some 400,000 cubic metres of dredged material. The negotiations also provided for use of the same leased territory on the Indian Reserve for a further 15 years for disposal of dredged material from the Cut-Off Channel only.

OCEAN DUMPING CONTROL ACT

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The Ocean Dumping Control Act (ODCA) was passed by Parliament in 1975 to reflect Canada's commitment to marine environmental quality and to fulfill our international obligations under the London Dumping Convention (LDC). The ODCA is part of Environment Canada's regulatory mandate and the Act concentrates on the Department's toxic substances priority. Both the LDC and the ODCA objectives pledge Canada to take effective measures to prevent marine pollution by dumping and to promote control of all sources of marine pollution.

Under the Act, disposal of wastes at sea is regulated through a system of permits and inspections administered by the Environmental Protection Service (EPS) of Environment Canada. The permit system is a preventative mechanism. The terms and conditions of a permit may vary with the type of substance being dumped. They reflect a commitment to protection human health, marine life and legitimate uses of the sea. Permits typically govern such things as timing, handling, storing, loading and placement at the disposal site.

Approximately 90% of the ocean dumping permitted is for the disposal of dredge spoil (13×10^6 m^3). One of the prevalent concerns is that toxics that had become sorbed to sediments pose an environmental threat when dredging or dumping remobilizes the toxics.

On the average, less than 10% of the dredge spoil intended for ocean disposal is considered highly contaminated. The challenge is to identify the practical availability, including technical feasibility and environmental soundness, of alternative land-based methods of treatment, disposal or elimination, or of treatment to render the matter less harmful for dumping at sea.

Other means of disposal are considered in light of a comparative assessment of:

- human health risks;
- environmental costs;
- hazards (including accidents) associated with treatment, packaging, transport and disposal;
- economics (including energy costs); and
- exclusion of future uses of disposal areas,

for both sea disposal and alternatives.

For disposal at sea we are primarily concerned about contamination and smothering effects in previous unexposed/unaffected dump sites. Disposal on land can have more serious consequences to the very sensitive nearshore environment than ocean disposal. In addition, land disposal presents additional environmental concerns like groundwater contamination which, although non-marine related, can be a serious environmental problem. While we have no exact figures, we estimate that less than 5% of the marine dredge spoils ends in confined land disposal (e.g. foreshore extensions or inland disposal sites).

In conclusion, the ODCA view is to use an holistic approach to compare disposal alternatives and thereby help ensure we use the best possible and practicable means of dredge spoil disposal.

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Appendix B

TERMS OF REFERENCE FOR THE DREDGING SUBCOMMITTEE
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AND

MEMBERSHIP OF THE DREDGING SUBCOMMITTEE

TERMS OF REFERENCE FOR THE DREDGING SUBCOMMITTEE OF THE WATER QUALITY PROGRAMS COMMITTEE

The Dredging Subcommittee (DS) will assist the Water Quality Programs Committee (WQPC) of the Great Lakes Water Quality Board (WQB) by:

a. Reviewing the existing practices and policies in both countries relating to dredging activities and their impact on the environmental quality of the Great Lakes system.

b. Maintaining a register of significant dredging projects being undertaken in the Great Lakes system with information to allow for the assessment of the environmental effects of the projects, including the long-term effect of both dredging and disposal of toxic sediments. The register shall include pertinent statistics to allow for the assessment of pollution loadings from dredged materials to the Great Lakes system.

c. Recommending procedures for encouraging the exchange of information relating to development of dredging technology and environmental research.

d. Identifying specific criteria for the classification of polluted sediments of designated areas of intensive and continuing dredging activities within the Great Lakes system.

e. Investigating the environmental impact of "In-place Pollutants" and recommending alternate strategies and options for mitigating various problems associated with the presence and/or removal of in-place pollutants, especially in case of "18 Class A Areas of Concern" identified in the 1982 Water Quality Board Report.

f. Preparing report and briefs pertaining to items listed above and other relevant topics and by undertaking special assignments as directed by the Water Quality Board.

Membership: The DS will be composed of representatives of the jurisdictions in the Great Lakes basin and the agencies engaged in dredging activities and, if necessary, recognized experts from the academic community and non-governmental organizations.

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